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ABSTRACT

This book contains three major sections. The first section provides 15 lesson plans for the integration of activities involving computer uses in mathematics instruction. Each lesson plan includes grade level, objective, time, materials, important terms, background, suggestions, and activities. The second section provides a list of available math software covering algebra; calculus; college math entrance examinations; geometry; graphing; logarithms; math games; basic math skills; problem solving; ratio and proportion; statistics and trigonometry. Each software entry delineates the concepts to be taught, the appropriate grade levels, software titles and publishers, suggested retail costs, the types of computer hardware, and location of software evaluations. The third section describes human cognition and the evaluation questions for three categories of learning outcomes: verbal knowledge; intellectual skills; and cognitive strategies. Indices for software titles and publishers are included. Sample software evaluation forms are appended. (YP)

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# MICROS AND SECONDARY MATH

## Lesson Plans, a Directory of Software for Achieving Specific Educational Objectives and Procedures for Evaluating Software

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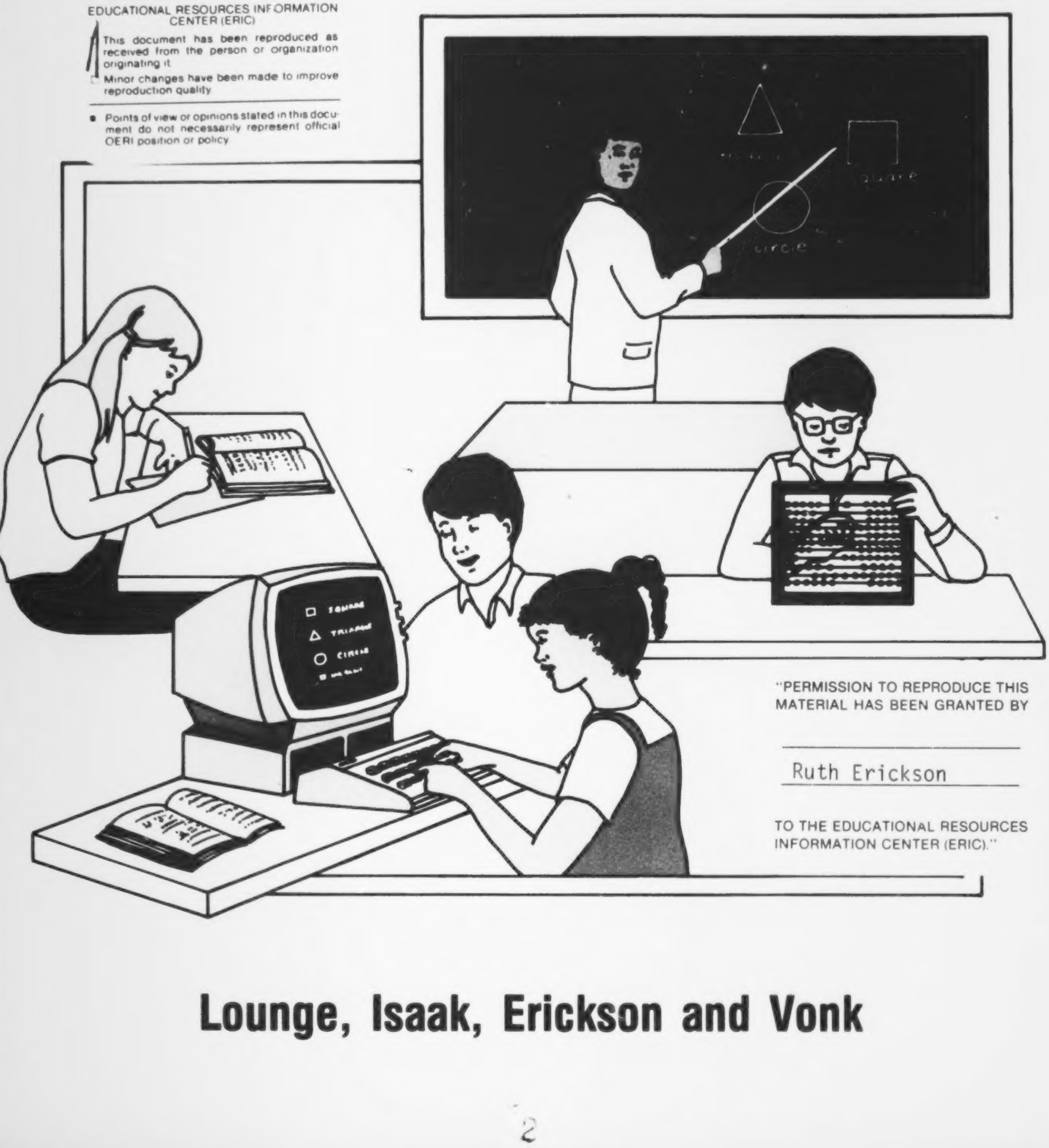

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# MICROS AND SECONDARY MATH:

## Lesson Plans, A Directory of Software For Achieving Educational Objectives and Procedures for Evaluating Software

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# Preface

The software directory in Micros and Secondary Math includes a fairly complete listing of commercially available software for teaching math concepts. However, it is impossible to identify every piece of available software. In future additions we will continue to add titles. If you are aware of any software that should be included in this directory, please send us your suggestions, preferably in the format used in the directory.

Mail your suggestions to:

Micros and Secondary Math
Learning Publications
P.O. Box 1326
Holmes Beach, FL 34218

A serious attempt to verify the validity and accuracy of each software listing, its appropriate concept and its hardware requirements, has been made. Of course, prices of software are subject to change and revision. We suggest that you check with the manufacturer or your distributor for current prices and availability. In addition, we make no representation or warranty regarding the contents hereof and specifically disclaim any implied warranties or merchantability or fitness for any particular purpose of any software or equipment. We also reserve the right to revise this publication and make periodic changes in the content hereof without obligation to notify any person or organization of such revision or changes.

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| Tandy Corporation: | Radio Shack TRS-80 Models I-IV, Model 16 |

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# Introduction

Micros and Secondary Math is organized in three major sections. The first section provides for the integration of microcomputer applications with math through model lesson plans based on learning outcomes. The second section presents a directory of available software for the secondary math teacher, while the third section describes procedures for evaluating software.

The lesson plans provide for the integration of activities involving computer uses into math instruction. These lesson plans may be modified to meet individual teaching styles. Furthermore, each lesson may be modified for individual use with one computer or for use with several computers in a computer lab. For this reason, the lessons are not sequentially ordered. Each lesson plan includes a set of computer activities plus off-computer activities that may be used to reinforce desired skills and knowledge. Many topics can be easily adapted as daily or weekly lessons or expanded into full quarter or semester topics.

The software directory provides a list of available math software. However, it directory is not intended to be an endorsement of any particular software. The software directory is generally organized around the same topics as the lesson plans. It includes the concepts to be taught, the appropriate grade levels at which to use the software, software titles and publishers, suggested retail costs, the types of computer hardware necessary to run the software and where to locate software evaluations.

The probability of educational gains in each subject area should be the focus of software evaluations. Unfortunately, most educational software evaluations are preoccupied with computer related, presentational and often superficial features of the software. For example, an evaluator may focus on the appearance of a program's graphics. Yet, teachers know that graphics, although they have eye appeal, may contribute little or nothing to desired student learning. Positive educational outcomes brought about by using the educational software is what is important. Using the evaluation criteria outlined in this book, teachers may increase the probability that any software they select will be appropriate for their teaching objectives.

# PART A
# LESSON PLANS

# LESSON 1

## Understanding Numeric Average

**GRADE LEVEL:** Grades 10 to 12

**OBJECTIVE:** When presented with a target number, students will be able to name three numbers that result in an average equal to the target number. The target number cannot be one of the three presented numbers.

**SUGGESTED INSTRUCTIONAL TIME:** One 45 minute session

**IMPORTANT TERMS:** Counterbalance, Average, Mean, Median

**BACKGROUND:** Concepts such as **average** are traditionally defined by a computational formula. For example, SUM / NUMBER OF FACTORS = AVERAGE. This simple and easily memorized formula is important. However, memorizing this formula is unlikely to lead to an understanding of the underlying concept of numeric average. Understanding the concept of numeric average is vital in statistics, problem-solving and some areas of higher mathematics.

**TEACHING SUGGESTIONS:** A day or two before starting this lesson, pass out the following puzzle to students.

PUZZLE:

> "Can you, without doing any addition, tell me the sum of the consecutive numbers, 0 through 100. For example, 0 + 1 + 2 + 3 + 4 . . . + 100. Remember you cannot use addition."

Give students a day or two to solve this puzzle. The answer alone is not sufficient. Students need to present the solution for solving the problem. Be sure to remind students to bring solutions to class.

Begin the lesson with a review of the computational formula for calculating a numeric average:

(SUM / NUMBER OF FACTORS = AVERAGE).

On the chalkboard, list, in ascending order, the height (in inches) of ten students. From this list, compute the average height of the sample using the conventional formula. Once students have calculated the average height, point out the values of the mean and the median. **Mean** is another term for numeric average. **Median** is the number at which half of the numbers are above and half of the numbers are below. That is, the median is the point at which 50% of observations fall above the midpoint and 50% fall below. Ask students to explain why mean and median are not the same. Be sure students understand these concepts before proceeding with the lesson. (If necessary, point out that several slightly shorter or taller than average heights counterbalance one or two very tall or short heights. **Counterbalance** is when equal amounts exist on both sides of a mid-point.)

Solicit possible solutions for the puzzle from students. Be sure to discuss each solution and its merit. On the chalkboard, write the following hints one at a time. With each hint, be sure to solicit possible answers for the puzzle.

Hint #1 COUNTERBALANCE

Hint #2 (100+0)/2 (0+100)/2
(99+1)/2 (1+99)/2
(98+2)/2 (2+98)/2

Hint #3 What is the average of all pairs? (50) How many averages are there? (101)

Once students understand the difference between mean and median focus on the term: Counterbalance.

Define counterbalance in terms of the balance of values on each side of the average. Remember, a number is an average if the values which are greater are balanced by those which are smaller. Ask students, "With counterbalance in mind, can you list three numbers whose average is equal to 12? Twelve cannot be one of the three numbers to average." If students are having difficulty, provide students with the following hint. "Think of two smaller numbers first. Now what must the larger number be?"

$$(X - S1) + (X - S2) = X - B$$

S1 & S2 = Small numbers
B = Big Number
X = Mean

**SUGGESTED CLASSROOM ACTIVITIES:**

On a computer, have students enter the following simple basic program.

```
10  SUM = 0
20  FOR N = 0 TO 100
30  SUM = SUM + N
40  NEXT N
50  PRINT SUM
60  END
```

Explain the function of each line of the computer program. Line 10 sets an initial value for the variable SUM. Line 20 begins a loop that will increase the variable N, by 1, each time the program loops. Line 30 adds the current value of SUM and the value of N and places that new value in SUM. Line 40 causes the program to return to line 20 and continue through the loop. Line 50 prints the final total of SUM. Point out to students that this simple program can be adapted to add even larger counts of numbers by changing line 20 to read:

```
20 FOR N = 1 TO (any number).
```

This simple computer program will verify the solution to the puzzle.

**REINFORCEMENT ACTIVITIES:**

Have students generate random numbers on a computer. From this list, have students determine if numbers are truly random. Use the concept of average to test to see if the numbers are truly random. The following program can be used to determine the average of a list of random numbers.

```
10    REM PROGRAM TO TEST RANDOM NUMBER GENERATOR
20    INPUT "HOW MANY NUMBERS DO YOU WANT ";MAX
30    DIM NUMB(MAX)
40    SUM = 0
50    FOR N = 1 TO MAX
60    NUMB(N) = INT(RND(1)*99+1)
70    SUM = SUM + NUMB(N)
80    PRINT NUMB(N);" ";
90    NEXT N
100   PRINT:PRINT "THE AVERAGE = ";SUM/MAX
```

If students are not familiar with programming statements, they may want to look up the meaning of each line in a BASIC programming manual.

Have students answer the following questions.

1. What do you expect the average to be? Why?

Hint: If numbers are truly random you should expect half of them to fall on one side of the average and half on the other side. The mean and median should be almost identical.

2. If you generate 10 random numbers, do you expect to get very close to the expected average? Try generating 10 random numbers several times.

3. If you generate 100 random numbers, what kind of results do you expect? How about with a thousand random numbers? Try generating 100 and 1000 random numbers several times.

The previously listed programs will work on a computer that uses Applesoft BASIC. If any other form of BASIC is used, consult the appropriate programming manual. Specifically, the command in line 60, INT(RND(1)*99+1), is an Applesoft BASIC random number generator. If another machine is to be used, consult the BASIC programming manual for instructions on generating random numbers.

# LESSON 2
# Converting Repeating Decimals to Fractions

**GRADE LEVEL:** Grades 10 to 12

**OBJECTIVE:** When presented with a repeating decimal, students will be able to convert it to a fraction.

**SUGGESTED INSTRUCTIONAL TIME:** One 45 minute period

**IMPORTANT TERMS:** Repeating Decimal, Scientific Notation

**BACKGROUND:** Although this specific skill has minimal (obvious) practical application, it does provide reinforcement and application of two important concepts in mathematics. The solution utilizes an elimination procedure central to the solution of open linear equations. For example, find the value of $X - 2x + 3 = 7x + 7$. Additionally, the format used provides a practical application for **scientific notation**.

**MATERIALS:** Chalkboard or Overhead Projector

**TEACHING SUGGESTIONS:** Discuss **repeating decimals** (for example, 25.666666->, 42.56565656->, 87.549549549549->). Introduce a labeling convention involving placing the repeating decimals in parentheses (e.g. 25.(6), 42.(56), and 87.(549)).

Have students try to figure out a way to deal with the repeating factor. If students do not seem to understand the problem, compare the factor with a non-repeating decimal. For example:

Problem:

Convert 30.56 to a fraction (3056/100)

Possible Solution:

Step 1 (Define the Problem):

We want to change the digits that repeat continuously into a number that has a distinct end.

Step 2:

Convert the problem into a form that will enable the repeating portion to be subtracted. For example:

.5656565656-> - .56565656-> = 0
.(56) - .(56) = 0

Step 3:

We must now figure out how to subtract a number from itself without ending up with 0. This can be accomplished by deriving two equivalent forms of the original equation with different magnitudes of the repeating decimal. The critical factor in this solution is that the repeating portion (to the right of the decimal) be identical in both equations. For example, with a repeating decimal of 30.(56) we would have to move the decimal TWO places to the right to retain a .5656565656-> repetition. If we move only one decimal place, we would have a 6565656-> repetition. In linear sentence format, this can be expressed as X = 3056.56/100, which is equivalent to the original decimal X = 30.(56).

Step 4:

In order to eliminate the repeating portion, we must isolate it on one side of the equation.

$$\begin{array}{lr} & 100X = 3056.(56) \\ & \underline{\;\;1X = \;\;30.(56)} \\ \text{Subtract equations} & 99X = 3026 \end{array}$$

Note: The problem causing repeating portion of the equation is now gone. Convert X to a fraction.

**CLASSROOM ACTIVITIES:**

Provide ample opportunity for practice by having students convert the following fractions:

40/27
43/11
57/22
41/22
44/27
65/12

Note: Fractions are displayed in computer format.

Have students use the computer in direct mode to convert the fractions to decimals. Direct mode refers to the use of print statements without a line number (e.g., PRINT 4698/999 will result in 4.702703 appearing on the monitor). Remind students, if necessary, that the computer will round a repeating decimal after a set number of digits. On an Apple computer, for example, a decimal will be rounded after six digits (e.g., 4698/999 = 4.702703).

**REINFORCEMENT ACTIVITIES:**

The problem solving process practiced in this lesson is as important as the development of the ability to deal with repeating decimals. Discuss the problem solving strategy as following a series of steps: 1) identifying the specific component causing the problem, 2) isolating that component, 3) eliminating that component, and 4) completing the solution of the original problem.

# LESSON 3
## Pascal's Triangle
## Binomial Expansion

**GRADE LEVEL:** Grades 10 to 11

**OBJECTIVE:** Students will use a microcomputer to demonstrate the pattern of coefficients which results from binomial expansion.

**SUGGESTED INSTRUCTIONAL TIME:** One 45 minute period

**IMPORTANT TERMS:** Coefficient, Binomial, Binomial Expansion

**BACKGROUND:** **Binomial expansion** is a concept that is often difficult for students to comprehend. A binomial expression can be expressed as $(X + Y)^n$. These symbols represent two quantities occurring in combination $(X + Y)$, the sum of which has an exponent of n. Binomial expressions are useful in solving problems of probability. To facilitate their understanding of binomial expansion, students can use the interesting pattern created among the coefficients of successive expansions. This pattern is called Pascal's Triangle after the well known French mathematician.

**MATERIALS:** Chalkboard, Overhead Projector, Paper and Pencil and/or a Microcomputer

**TEACHING SUGGESTIONS:** Students should have prior experience with the following concepts as a prerequisite to this lesson:

a) mononomials
b) polynomials
c) factoring of quadratic equations

Be sure to review each concept for student comprehension before proceeding with this lesson. If students are having difficulty proceeding beyond this review, stop the lesson and provide instruction on the prerequisite topics.

**CLASSROOM ACTIVITIES:** Once students have demonstrated an understanding of monomials, polynomials and factoring of quadratic equations, introduce them to the concept of binomial expansion.

Have students use paper and pencil to expand each **binomial** using **coefficients** from 1 to 4.

Once students are able to calculate binomial expansion on paper, explain that a computer can provide a valuable aid for this type of calculation. Have students type the following into the computer.

```
100  LET CTR = 18:REM  TO CENTER DISPLAY
110  PRINT SPC(CTR);"1"
120  PRINT SPC(CTR-2);"1{3}1"
130  PRINT SPC(CTR-4);"1{3}2{3}1"
140  PRINT SPC(CTR-6);"1{3}3{3}3{3}1"
150  PRINT SPC(CTR-8); "1{3}4{3}6{3}4{3}1"
160  PRINT SPC(CTR-10); "1{3}5{3}10{2}10{2}5{3}1"
170  PRINT SPC(CTR-12); "1{3}6{3}15{2}20{2}15{2}6{3}1"
```

Note: The { } indicate number of spaces.

The program listed above will work on a computer that uses Applesoft BASIC. If any other form of BASIC is used, consult the appropriate programming manual.

Challenge students to compare the results of their previous expansion efforts with the triangle. Ask them to look for relations between binomial expansion coefficients and a triangle line. In addition, have them compare the relationship between lines in Pascal's Triangle.

Have students state the coefficients of the fifth and sixth expansion of (a + b) without calculating them (use the triangle).

Hint: Add two numbers in the prior line.

Note: This exercise can be used without a computer; however, a computer may enhance student interest.

**REINFORCEMENT ACTIVITIES:**

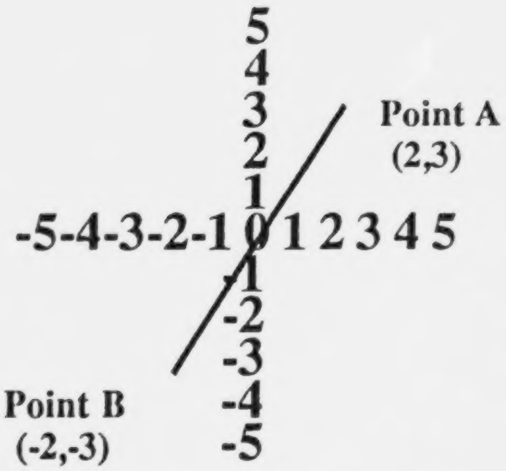
Have students identify coefficients of seventh and eighth order expansions without expanding the expressions by hand. This can be done easily by completing the next two lines of Pascal's Triangle.

# LESSON 4

## Linear Equations

## Linear Relationship Between Two Variables

| | |
|---|---|
| **GRADE LEVEL:** | Grade 9 to 10 |
| **OBJECTIVE:** | Students will recognize an equation as representing a linear relationship.<br>Students will distinguish the components of slope and y-intercept within a **linear equation.** |
| **SUGGESTED INSTRUCTIONAL TIME:** | Two 45 minute sessions |
| **IMPORTANT TERMS:** | Slope, Y-Intercept, Linear Equation |
| **BACKGROUND:** | A linear relationship between two variables (x,y) has important problem solving implications. That is, it is important to understand the effect of one variable on another in order to solve a specific problem. For example, many naturally occurring variables form a linear relationship with others (e.g., an automobile's range and its miles per gallon). This lesson uses a simple computer simulation to help students understand the parameters of a straight line relative to a vertical and horizontal axis. |
| **MATERIALS:** | Chalkboard, Overhead Projector and/or Microcomputer |
| **TEACHING SUGGESTIONS:** | Before starting this lesson, insure that students have a working knowledge of the graphic format representing an (x,y) axis. In addition, they should have an understanding of the common (x,y) coordinate addressing system. If students do not have these prerequisite skills, do not continue with this lesson until they are able to demonstrate these skills.<br>Begin this lesson by reviewing the (x,y) axis format. On the chalkboard, draw the diagram on the following page: |



Place a single point on this diagram. Explain to students that each point of the diagram is labeled with the x-axis first and the y-axis second. For example, **point A** is labeled (2,3) and **point B** is labeled (-2,-3).

Draw a line between points A and B. Explain to students that this line represents a linear relationship. It is called a linear relationship because the line is straight. This line can be represented in the following formula:

$$y = bx + c$$

Point out to students that the y in this formula represents the number on the y axis and the x represents the point on the x axis. B in this formula represents the **slope**. That is, the change in x as caused by y. In this example, the line drawn between points a and b represents a slope of 1. C represents the point at which the line intercepts the y axis. In this example, the line crosses the y axis at 0.

On the chalkboard, pick several new points and have students calculate the slope and intercept.

SUGGESTED
CLASSROOM
ACTIVITIES:

Discuss with student the effects of changing b and c. Students should be able to explain the results of a line with a slope of 0 and a slope of 1. Have them graph several different lines on paper. When students are finished, they can verify their graphs by typing the **slope** (b) and **y-intercept** into the computer.

The following computer program provides students with a simulation to help students discover the effects of changing the values of b and c.

```
100  REM PROGRAM TO PLOT ST LINES
110  HOME:PRINT
120  PRINT SPC(10);10
130  PRINT SPC(5);"Y";SPC(4);9
140  PRINT SPC(10);8
150  PRINT SPC(10);7
160  PRINT SPC(5);"A";SPC(4);6
170  PRINT SPC(5);"x";SPC(4);5
180  PRINT SPC(5);"i";spc(4);4
190  PRINT SPC(5);"S";SPC(4);3
200  PRINT SPC(10);2
210  PRINT SPC(10);1:PRINT SPC(11);
220  FOR I = 1 TO 10
230  PRINT I;
240  NEXT I
250  PRINT:PRINT:PRINT
260  PRiNT "        x - axis"
270  INPUT "Y-INTERCEPT = ";C
280  INPUT "SLOPE = ";B
290  FOR P = 2 TO 10
300  X = P
310  Y = INT(B*X+C)
320  IF Y > 10 THEN GOTO 410
330  K=-10
340  FOR J = 10 TO Y STEP -1
350  K=K+2
360  NEXT J
370  VTAB Y + K
380  HTAB X + 11
390  PRINT "*"
400  NEXT P
410  VTAB 18
420  PRINT "PRESS ANY KEY TO CONTINUE ":GET CNTU$
440  GOTO 110
```

The program listed above will work on a computer that uses Applesoft BASIC. If any other form of BASIC is used, consult the appropriate programming manual.

NOTE: This simulation uses the normal text mode, allowing numbers to be written on the screen. The disadvantage is that the (x,y) axis dimensions are not equally proportioned. The result is a line that zig-zags at various slopes. It is therefore recommended that this exercise only be used when it is important for students to visualize the numbered increments along each axis. See **Lesson 7** for a simulation that plots in a properly proportioned scale.

**REINFORCEMENT ACTIVITIES:**

Provide a scatter diagram which contains an obvious linear relationship between the variables representing the (x,y) axis. Have students graph a straight line within the scatter diagram. Also ask them to calculate the slope and y-intercept of this line. Discuss the idea that an approximation of a straight line from a variable set of data is the norm in naturally occurring events.

# LESSON 5
## Linear Number Line

**GRADE LEVEL:** Grade 7 to 9

**OBJECTIVE:** Given a straight line on a graph, students will determine the line length between any two points on the line.

**SUGGESTED INSTRUCTIONAL TIME:** Two 45 minute sessions

**IMPORTANT TERMS:** Integer, Absolute Value, Number Line

**BACKGROUND:** Determining the length of a line between any two points is often an easy procedure. However, this process has important conceptual implications. For example, the operation of a slide rule is based on simple point-to-point length measurement. This lesson provides a quick review to studying exponential growth and logarithms. Extensive attention is devoted to graphing and solving linear equations in the typical mathematics curriculum. This exercise provides one example of a practical application.

**MATERIALS:** Chalkboard, Overhead Projector, Microcomputer and Printer

**TEACHING SUGGESTIONS:** On the chalkboard, draw a simple **number line** using integers from -9 to +9. Review the concepts and symbols of absolute value and integers with students. They should understand that **integers** are whole numbers, and the **absolute value** of any number is that number without regard to being positive or negative. For example, the integer -9 has an absolute value of 9. This absolute value is represented by $|9|$.

Point out to students that the equation for adding numbers on a number line involves adding the absolute values of the numbers. For example, adding -9 to 8 is accomplished with the equation $|9| + |8| = 17$.

**SUGGESTED CLASSROOM ACTIVITIES:** Using a microcomputer with a printer, have students create two number lines. The first number line should consist of increments from 1 to 20. The second number line should contain increments from -9 to +9. The following computer program can be used to create these number lines.

```
100  REM PROGRAM TO PRINT NUMBER LINES
110  PR#1:REM SELECT PRINTER
120  FOR I = 0 TO 9
130  PRINT I;"  -"
140  NEXT I
150  FOR I = 10 TO 20
160  PRINT I;" -"
170  NEXT I
180  PRINT:PRINT:PRINT:PRINT

220  FOR I = 9 TO 1 STEP -1
240  PRINT I * -1;" -"
260  NEXT I
280  FOR I = 0 TO 9
300  PRINT "+";I;" -"
320  NEXT I
340  END
```

The program listed above will work on a computer that uses Applesoft BASIC. If any other form of BASIC is used, consult the appropriate programming manual.

Once students have created these two number lines, provide them with a series of integer pairs (e.g., -6 and +4), and have them determine the sums using the number lines.

Number lines correspond to the vertical spacing printed out by the computer. Prior to using the number lines on graphed lines, students should create a work sheet with appropriate spacing between lines.

Have students graph a series of straight lines. Indicating a pair of points on each, have them determine the distance between each point using the number line. In addition, have students calculate the distance using absolute values. Ask them which method they prefer in calculating the answers.

**REINFORCEMENT ACTIVITIES:**

Instead of providing two sets of coordinates and asking for the distance between the two, provide one set of coordinates and a distance. Ask students to discuss the situation involved with the resulting graph. Realizing that a specific direction value is required will be a good review as well as a good introduction to the concept of slope.

To give students more practice in creating number lines, use the program listed in this lesson. To make any length of number lines, change the last value in line 150 to any number (greater than ten). The length of that line will correspond to the new value.

# LESSON 6
## Exponential Growth Curve
## Conceptual Approach

**GRADE LEVEL:** Grades 9 to 11

**OBJECTIVE:** Students will calculate values which, when graphed, will demonstrate exponential growth.

**SUGGESTED INSTRUCTIONAL TIME:** Two 45 minute sessions

**IMPORTANT TERMS:** Exponential Growth Curve

**BACKGROUND:** **Exponential growth** is a common and important phenomenon in any natural system, for example, population growth. This lesson provides students with the opportunity to learn and work with values which increase exponentially. Additionally, this lesson provides students with practice using a computer in both a programming and a direct mode of operation.

**MATERIALS:** Chalkboard, Overhead Projector and Microcomputer/Calculator

**TEACHING SUGGESTIONS:** Begin this lesson by challenging students to answer the following question:

> "You are offered a temporary job for summer vacation (20 days). The salary is only two pennies for the first day, four pennies for the second, and sixteen on the third. This trend continues through day 20. The work is hard, dirty and unpleasant. Would you take the job?"

After allowing students time to think about their answers, record several guesses as to the total salary on the chalkboard. Be sure to ask them how they arrived at their amount of pay. Once students have provided some possibilities, list on the chalkboard the days and the amount of pay per day. Have them add up the total amount. Ask if they would take the job now.

**SUGGESTED CLASSROOM ACTIVITIES:** Point out the pattern of daily pay increases to students. Explain that this pattern is known as **exponential growth**. This can be represented by the following formula $y = x^2$. Have students develop a short computer program to determine the answer to the problem above. Since this requires a relatively simple and short program, you may want to let students attempt to design, as well as input, the program. An example is included below. An option of doubling growth is included which demonstrates a slower growth rate. Exponential growth is so rapid that the visual pattern is not always apparent.

```
100  REM A SIMPLE GROWTH CURVE
110  DIM DAY(20):DIM TTL(20):DIM TTL$(20):DIM DAY$(20)
120  LET DAY(1)=2
130  INPUT "What kind of growth do you want to see? (D=DOUBLE
     E=EXPONENTIAL) ";CHOICE$
140  FOR I = 2 TO 20
150  IF CHOICE$ = "E" THEN GOTO 170
160  LET DAY(I) = (DAY(I-1) + DAY(I-1):GOTO 180
170  LET DAY(I) = (DAY(I-1) * DAY(I-1)
180  IF DAY(I) > 99999999 THEN DAY(I)=99999999
190  LET TTL(I) = TTL(I-1) + DAY(I)
200  LET TTL$(I) = "$" + STR$(TTL(I)/100)
210  LET DAY$(I) = "$" + STR$(DAY(I)/100)
220  NEXT I
230  END
```

*ADD THE FOLLOWING LINE TO GET AN AUTOMATIC OUTPUT

```
215  PRINT "DAY ";I;" = ";DAY$(I)
```

The program listed above will work on a computer that uses Applesoft BASIC. If any other form of BASIC is used, consult the appropriate programming manual.

Students can also solve the problem without designing and executing a computer program. This method is known as the direct mode. **Direct mode** means that commands will be executed when they are entered rather than later when the program is RUN. The direct mode does not allow the use of line number. Have students explore the total and partial values by solving this problem in direct mode. Following are the steps needed for use in the direct mode. After running the program above, ask students:

Question: What is the salary for the day?

Command: PRINT Day$(?)

Question: What would the total accumulated earnings be on ? day?

Command: PRINT Tot$(?)

**REINFORCEMENT ACTIVITIES:**

After students have seen the effect of doubling the values (option D), have students select option E (exponential growth). Discuss the difference between the two growth rates.

# LESSON 7
## Exponential Growth Curve Visualization Approach

**GRADE LEVEL:** Grades 9 to 11

**OBJECTIVE:** Students will create a graph which represents exponential growth.

When presented with a variety of graphed equations, students will recognize the ones which represent exponential growth.

**SUGGESTED INSTRUCTIONAL TIME:** Two 45 minute sessions

**IMPORTANT TERMS:** Exponential Growth Curve

**BACKGROUND:** When exponential growth is graphed, a curve is created. When students can see this shape, it may contribute to their understanding of the underlying relationships between variables.

**MATERIALS:** Chalkboard, Overhead Projector and Microcomputer

**TEACHING SUGGESTIONS:** Review with students the concept of exponential growth described in Lesson 6. Point out that exponential growth is achieved whenever a value which increases one integer at a time has a corresponding value which is the result of raising each integer to a specified power or exponent. For example:

| Value | Corresponding Value |
|---|---|
| 1 | $1^3 = 1$ |
| 2 | $2^3 = 8$ |
| 3 | $3^3 = 27$ |

Explain to students that an exponential growth equation differs from a linear equation. A linear equation can be graphically represented by using a straight line on an (x,y) axis graph. Exponential growth is represented on an (x,y) axis graph using a uniquely shaped, curved line.

Challenge students to try to visualize a graph representing exponential growth. Point out that exponential growth is characterized by a curved line. A demonstration of an **exponential growth curve** is included in the program provided with this lesson.

On the chalkboard, draw an (x,y) axis with the **x axis** labeled "days" and the **y axis** labeled "money." Next to the graph, list the day and amount of money paid in the penny problem in Lesson 6. Create point coordinates for the day and amount. Place these points on the graph. As you place each point on the graph, ask students if they see a pattern developing. Ask them if the line created by connecting each point will be linear or curved.

## SUGGESTED CLASSROOM ACTIVITIES:

Once students have seen the development of a graph representing exponential growth, provide them with access to a microcomputer and a program that allows them to easily create these graphic programs. Allow students ample time to discover the effect of graphing an exponential equation compared to the effect of graphing a linear equation.

The following program allows students to visualize exponential growth. However, this program only simulates positive exponents.

```
100  REM PROGRAM TO SIMULATE LINEAR AND
     EXPONENTIAL CURVES
110  DIM Y(200):XMAX=150:YMAX=150
120  HGR:HCOLOR=3
130  HPLOT 0,0 TO 0,YMAX
140  HPLOT 0,YMAX TO XMAX,YMAX
150  PRINT "WHICH FUNCTION DO YOU WANT?"
160  PRINT "L=LINEAR  E=EXPONENTIAL   C=CLEAR":PRINT
170  INPUT CHOICE$
180  IF CHOICE$ = "L" THEN GOSUB 500
190  IF CHOICE$ = "E" THEN GOSUB 700
200  IF CHOICE$ = "C" THEN GOTO 120
210  PRINT "PRESS ANY KEY TO CONTINUE":GET CNTU$
220  GOTO 150
500  REM  LINEAR SUB
510  INPUT "SLOPE = ";B
520  INPUT "Y-INTERCEPT = ";C
530  FOR X = 1 TO XMAX
540  Y=INT(B*X+C)
550  Y=YMAX-Y
560  IF Y < 1 THEN GOTO 590
570  HPLOT X,Y
580  NEXT X
590  RETURN
700  REM  EXPONENTIAL SUB
710  INPUT "WHAT EXPONENT ";E
720  FOR X = 1 TO XMAX
730  Y(X)=1
740  FOR I = 1 TO E
750  Y(X)=Y(X)*X/12
760  NEXT I
770  Y(X)=YMAX-Y(X)
```

```
780  IF Y(X) < 1 THEN GOTO 810
790  HPLOT X,Y(X)
800  NEXT X
810  RETURN
```

The previously listed program will work on a computer that uses Applesoft BASIC. If any other form of BASIC is used, consult the appropriate programming manual.

Note: The program used in this lesson may be used in other lesson plans. Save it on a disk to save time. Consult the DOS manual if unsure as to how to do this.

**REINFORCEMENT ACTIVITIES:**

Ask students to browse through some biology and physics textbooks to find examples of exponential growth. A computer simulation of a naturally occurring event which demonstrates exponential growth could provide a special project for students.

# LESSON 8
## Straightening Out the Exponential Curve
## An Introduction to Logarithms

**GRADE LEVEL:** Grades 10 to 11

**OBJECTIVE:** Students will use an exponential curve to construct a logarithmic scale.

**SUGGESTED INSTRUCTIONAL TIME:** Two 45 minute sessions

**IMPORTANT TERMS:** Logarithm, Exponential Curve

**BACKGROUND:** Multiplying large numbers by adding **logarithms** is a concept based on rules for multiplying exponents. This lesson provides students with the opportunity to incorporate concrete manipulation to construct an **exponential growth curve** into a logarithmic scale.

**MATERIALS:** Chalkboard, Overhead Projector and Microcomputer

**TEACHING SUGGESTIONS:** Before beginning this lesson, review the concept and usefulness of the linear equation $y = bx + c$. In addition, review a function of this linear equation with students. For example, students should be familiar with the descriptive parameters of slope and y-intercept and comparison of two or more linear equations.

On a chalkboard, review the shape of an exponential curve ($y = x^2$). Have students draw an exponential curve representing population growth. If they have difficulty with this task, ask them to run the program from Lesson 7 as an example.

**SUGGESTED CLASSROOM ACTIVITIES:** Ask students to imagine what would happen to the spacing of the numbers on the x-axis if the curve were straightened. Again, if they have difficulty with this question, follow up by asking them to consider the following question:

> Assuming a maximum value for x of 20, in equally spaced increments ments of 10, what would each corresponding y value be?

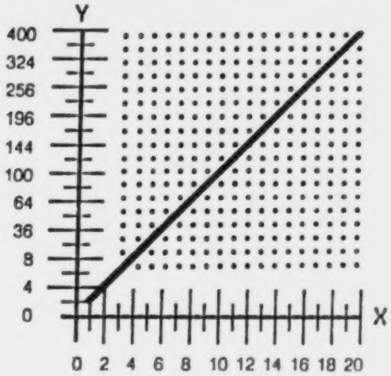
Give students ample time to think about the question. You may wish to provide them with the following hints:

1. Build a table of x and y values for the original exponential function $y = x^2$.

2. Use a calculator or computer (in direct mode) to compute the values of x and y. PRINT SQR (a value) will produce the square root of the value. PRINT (a value) * (a value) will produce the value squared. If $y = x^2$ then x = (the square root of y). For example:

| Y | given X |
|---|---|
| 400 | 20 |
| 1600 | 40 |
| 3600 | 60 |
| 6400 | 80 |
| 10000 | 100 |

Emphasize that the spacing on the Y-axis gets progressively smaller and smaller. Graph the formula $x = y^2$ using the values of x from 0 to 20 and the calculated y values as the (x,y) axis values.



**REINFORCEMENT ACTIVITY:**

Have students calculate the x-axis values for y-axis values between 0 and 20 (i.e., x = (the square root of Y)).

| Y | given | X |
|---|---|---|
| ? | | 0 |
| ? | | 2 |
| ? | | 4 |
| ? | | 6 |
| ? | | 8 |
| ? | | 10 |
| ? | | 12 |
| ? | | 14 |
| ? | | 16 |
| ? | | 18 |
| ? | | 20 |

# LESSON 9
## Logarithms

**GRADE LEVEL:** Grades 9 to 11

**OBJECTIVE:** Students will determine products and quotients using logarithms.

**SUGGESTED INSTRUCTIONAL TIME:** Two 45 minute sessions

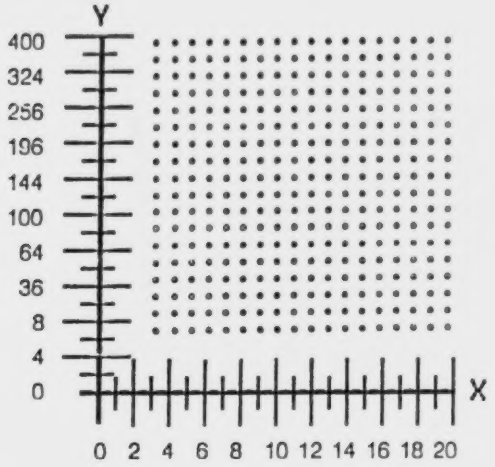
**IMPORTANT TERMS:** Logarithm

**BACKGROUND:** Helping students consolidate the concept of a linear number line with the conversion of an exponential function to a linear representation (Lesson 8) can contribute to a better understanding of **logarithms.** This lesson provides students with the opportunity to make that connection in a practical application.

**MATERIALS:** Chalkboard, Overhead Projector, Microcomputer, Slide Rule

**TEACHING SUGGESTIONS:** Review the meaning and application of the terms logarithm and exponent. If students are having difficulty grasping these concepts, stop this lesson and provide the necessary instruction for them to be able to fully understand each concept independently.

Review with students the effect of straightening out an exponential curve on the scales. For example, look at the y scale on the following graph. Note that the larger the number on the y-axis, the smaller the spread between the increments on the scale.



Challenge students to figure out a way to multiply and divide using exponents. After allowing students to struggle with this problem, introduce the following rules involving operations with exponents:

^ = exponent

a^i * a^j = a^i + j

In other words, $a^2$ times $a^3$ equals $a^5$. One simply adds the exponents.

a^i/a^j = a^i-j^

Similarly, $a^4$ divided by $a^2$ equals $a^2$. One simply subtracts the exponents.

Introduce students to the laws of logarithms. Be sure to discuss the following conditions:

"a" is positive and not equal to 1, "p" and "q" are positive and "n" is any real number.

The laws of logarithms include:

a) log^a^PQ = log^aP + log^aQ

The sum of the logs of two values is equal to the log of the products of the two values.

b) log^aP/Q = log^aP - log^aQ

The difference between the logs of two values is equal to the log of the quotient of two values.

**SUGGESTED CLASSROOM ACTIVITIES:**

Using a slide rule, demonstrate the process of multiplication and division. Verify the products and quotients calculated on a slide rule with a computer in a direct mode.

Allow students to use a computer in direct mode to multiply and divide using logarithms. Students should write down each step for future reference. Be sure to discuss the function of each step in order to help students better understand this process. Type the following steps on a handout for students to follow:

1. Convert factors to their logarithm
   PRINT LOG(number)

2. Add logs mentally

3. Covert log of product or quotient back to original form
   PRINT EXP(number)

**REINFORCEMENT ACTIVITIES:**

Have students design a hand held (non-electrical) tool to calculate products and quotients. Students should be encouraged to struggle with this problem for a while. Eventually, students should come up with a design much like a slide rule to calculate products and quotients. Of course, students should also be encouraged to use some of the software identified in the Software Directory.

# LESSON 10
# Graphing a Parabola
# A Computer Simulation

**GRADE LEVEL:** Grades 10 to 11

**OBJECTIVE:** Students will view the graphic representation of a parabola including the effects of changing its parameters.

**SUGGESTED INSTRUCTIONAL TIME:** Two 45 minute sessions

**IMPORTANT TERMS:** Parabola, Axis of Symmetry, Vertex

**BACKGROUND:** Developmental psychologist, Jean Piaget, noted that the cycle from concrete to abstract learning applies to any novel experience regardless of age. For example, to learn how to add, one manipulates concrete objects before adding abstract numbers. Computer simulation offers the advantage of concrete manipulation of abstract concepts. The following lesson allows students to discover the effects of changing the parameters of a graphic (concrete) representation of a **parabola** (an abstract concept).

**MATERIALS:** Chalkboard or Overhead Projector, Microcomputer

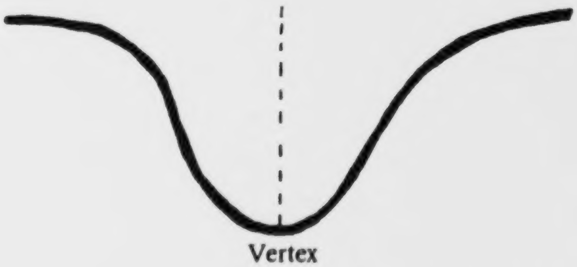
**TEACHING SUGGESTIONS:** Begin this lesson with a practical application example for a parabola. Ask students to describe or explain how a parabola may be used in everyday life. Asking them to think of a practical application for a mathematical concept with a unique property can be quite challenging. It is expected that students will be unable to think of an example. Help them to discover the theory behind the satellite dish with the following discussion. Do not give them hints without having provided ample information and time for discovery.

One practical application of a mathematical concept represented by the parabola involves a number of parallel straight lines all converging on one common point. Point out to students that these lines can be reflected but cannot bend. On the chalkboard, draw the following display.

```
------------>
------------>
------------>             •
------------>
------------>
------------>
```

Ask students what shape of object would be needed to achieve the necessary reflection. (Answer: a parabolic shape) Be sure to solicit several alternatives. Allow students to come to the chalkboard to display their ideas. Once they have had an opportunity to experiment, draw a parabola and demonstrate the property of reflective convergence on a common spot. If they cannot think of any practical application for a parabola, suggest a satellite dish.

Define axis of symmetry and vertex. Explain to students that **symmetry** means two sides of equal shape. **Vertex** is the point farthest from the base of a figure. For example,



Once students develop a visual understanding of a parabola, tell them that a parabola can be represented in a mathematical equation. Following is the mathematical equation for a parabola.

$$y = a(x-h)^2 + k$$

In this equation, y and x are variables, while a, h and k are constants. Ask students to visualize the effects of changing the values of h and k.

### SUGGESTED CLASSROOM ACTIVITIES:

Once students have developed an understanding of the mathematical representation of a parabola, they may increase their understanding of the changing values of h and k with the following computer program.

```
90    DIM EXFAC(250)
100   REM GRAPHIC SIMULATION
110   XMID = 90:YMID = 90
120   HGR : HCOLOR= 3
125   H = 0:K = 0
130   HPLOT 0,YMID TO 2 * XMID,YMID
140   HPLOT XMID,0 TO XMID,2 * YMID
150   INPUT "LET A= (1.1-1.9) ";A
155   IF A > 1 THEN GOTO 180
160   INPUT "LET H= (1-4) ";H
170   INPUT "LET K= (1-4) ";K
180   LET K = K * 10
```

```
200  FOR X = 9 TO 1 STEP - 1
210  Y = ((X + H) * (X + H) * A) + K
220  X1 = XMID - X * 10
230  X2 = XMID + X * 10
240  HPLOT X1,Y
250  HPLOT X2,Y
260  NEXT X
500  PRINT "PRESS ANY KEY TO CONTINUE"
510  GET CNTU$: GOTO 120
520  END
```

The program listed above will work on a computer that uses Applesoft BASIC. If any other form of BASIC is used, consult the appropriate programming manual.

Allow students to enter and edit this computer program. Once entered, students can use this program to help develop their understanding of parabolas and the effects of h and k.

Once students have been allowed time to discover the effects of changing the parameters with this computer program, ask them the following questions:

1. What happens when $a > 0$, $a < 0$ ?

2. What happens when $h > 0$, $h < 0$ ?

3. What happens when $k > 0$, $k < 0$ ?

4. What is the difference between a small and large value of a, h, k ?

Review the answers to each of these questions in class. If students are still having difficulty, allow them more time to work with the computer program.

**REINFORCEMENT ACTIVITIES:**

Provide a list of equations representing a variety of figures (parabola, straight lines, and circles). Have students pick out those that will result in a parabola. Also provide ample opportunities for students to use software identified in the Software Directory section of this book.

# LESSON 11
## Permutations

**GRADE LEVEL:** Grades 9 to 11

**OBJECTIVE:** When presented with a specified number of objects grouped into a specified number of subgroups, students will calculate the number of possible subgroups.

**SUGGESTED INSTRUCTIONAL TIME:** Two 45 minute sessions

**IMPORTANT TERMS:** Permutation, Factorial

**BACKGROUND:** The concept of **permutation** has many practical applications. Permutations can be defined as the number of unique sets which can be formed from a specified number of objects. The calculation of permutations is relatively straight forward and does not require sophisticated mathematics. The solution is based on the **factorial** concept which requires that each number in a sequence of numbers be multiplied by the next number. The redundancy involved with factorials makes it a phenomenon to illustrate on a computer. This lesson will provide students with the opportunity to practice solving practical problems by hand as well as with a computer.

**MATERIALS:** Chalkboard or Overhead Projector, Microcomputer

**TEACHING SUGGESTIONS:** Introduce the concept of permutation by having students consider the following problems. Imagine a situation where you are pairing up teammates for a racquetball tournament. There are 20 individual players and each team is composed of only two players. Place the names on individual slips of paper and draw them, two at a time, from a hat. The first person selected in each pair is designated the captain.

In this situation it would not make sense to replace the names in the hat as a player can only be on one team. Yet, how many different outcomes are possible for the first team selected? This may be easier to understand if one considers how many possible outcomes are available on the first draw. The number possible is equal to the number of slips in the hat, in this case, 20.

Remember that slips are not returned to the hat, so, "How many are available for the second draw?" (20 - 1 = 19) "How many for the third draw?" (19 - 1 = 18) In the current problem, however, we are interested in the possible number of sets of two to be drawn from twenty single items.

There are twenty possible outcomes on the first draw. For each of these possibilities, there are 19 possibilities on the second draw. The total number of possibilities for the first team (2 players) is therefore 20 * 19 or 380.

Each possible ordered set of names is called a permutation. Ordering of each set involved is based on the first person selected in the pair. This is known as the captain. In this example, there are twenty objects, drawn 2 at a time. A formula is available for calculating permutations of any number of items taken any number at a time. First some definitions:

> When finding the number of possibilities for each draw from the hat, multiply the previous number of items by the current number (1 less). This process is called factorial and is designated in a formula by an exclamation point (!).
>
> $6! = 6 \times 5 \times 4 \times 3 \times 2 \times 1$
> $20! = 20 \times 19 \times 18 \times 17 \ldots \times 1$
>
> Let n = the total number of objects that can be drawn.
>
> Let r = the number of objects that are put into subgroups.
>
> The general formula for calculating permutations is: $n!/(n-r)!$

Use this formula in an actual example. Find the number of permutations of 10 objects using 3 at a time.

$$\frac{10!}{(10-3)!}$$

$$= \frac{10!}{7!}$$

$$= \frac{10 \times 9 \times 8 \times 7 \times 6 \times 5 \times 4 \times 3 \times 2 \times 1}{7 \times 6 \times 5 \times 4 \times 3 \times 2 \times 1}$$

$$= 720$$

**SUGGESTED CLASSROOM ACTIVITIES:**

Students should be allowed to practice hand calculating a number of permutation problems. Hand calculation is quite difficult, however, when the factorials are large.

The following computer program can be used to verify hand calculation when larger numbers are involved.

```
100  REM PERMUTATION CALCULATION
110  NIAL = 1:RIAL = 1
120  INPUT "ENTER THE NUMBER OF OBJECTS ";N
```

```
130  PRINT
140  PRINT "ENTER THE NUMBER OF OBJECTS"
150  INPUT "USED AT ONE TIME ";R
160  FOR NFAC = N TO 1 STEP - 1
170  NIAL = NIAL * NFAC
180  NEXT NFAC
190  FOR RFAC = N - R TO 1 STEP - 1
200  RIAL = RIAL * RFAC
210  NEXT RFAC
220  PRINT "THE NUMBER OF PERMUTATIONS = ";NIAL / RIAL
240  END
```

The program listed above will work on a computer that uses Applesoft BASIC. If any other form of BASIC is used, consult the appropriate programming manual.

**REINFORCEMENT ACTIVITIES:**

Extend the concept of permutation to the concept of combination. A combination differs from a permutation in that the order of objects in the subset is not important.

$$\text{Combination} = \frac{n!}{r!(n-r)!}$$

Ask students to solve the following problems:

1) How many different hands of five cards can be drawn from an ordinary deck of fifty-two playing cards?

2) How many two person teams can be selected from a roster of 16 players when both team members are of equal rank (no captain)?

# LESSON 12
# Scientific Notation

**GRADE LEVEL:** Grades 7 to 9

**OBJECTIVE:** Students will be able to convert any decimal number to its scientific notation equivalent.

**SUGGESTED INSTRUCTIONAL TIME:** Two 45 minute sessions

**IMPORTANT TERMS:** Scientific Notation

**BACKGROUND:** **Scientific notation** is used to represent very large and very small numbers in a limited space. Scientific notation format has some distinctive advantages. Most significant digits are isolated with the scientific format and therefore become very apparent (e.g., $8 * 10^6$). Scientific notation also provides an obvious order of magnitude enabling a quick estimate when performing an arithmetic operation. In addition, microcomputer applications in mathematics use scientific notation extensively.

**MATERIALS:** Chalkboard or Overhead Projector, Microcomputer

**TEACHING SUGGESTIONS:** On a chalkboard, demonstrate the difficulty encountered when dealing with large numbers of digits (e.g., 47362.843 X .00043629). Explain to students that multiplying these numbers by hand is often difficult and subject to a great deal of error.

Review multiples of ten involving decimal numbers. Explain to students that when a decimal number is multiplied by ten the decimal is shifted to the right. For example, 345.67 X 10 = 3456.7. When a number is divided by ten, the decimal is shifted to the left. If students are not familiar with this concept, allow time for them to practice multiplying and dividing by 10, 100 and 1000.

Once students understand the concept of multiples of ten, review the concept of **significant digit**.

Ask students:

> Which is the most significant digit of .00043629?
> (Answer = 4)
>
> Why bother with significant digit?
> (Answer = estimation and approximation)

Students should understand that the concept of significant digit is used in estimation and approximation.

On a chalkboard write the following two numbers:

0.000436929
436.929

Ask students to use a multiple of 10 to isolate the significant digit in each multiple digit number.

Point out to students that in each example the significant digit is 4. This is the digit that contributes most to the value of the number. Ask students what must be done to isolate 4 as the digit just to the right of the decimal place.

In example 1. 4.36929 / 1000 = .000436929

In example 2. 4.36929 * 100 = 436.929

[Note: Computers use / to represent division and * to represent multiplication.]

Discuss the problem of finding a common format for dividing by 1000 and multiplying by 100.

Hint: Multiples of 10 can be expressed as 10 with an exponent.

Ask students to complete the following equations:

$10^{2}$ = ____________
$10^{-2}$ = ____________
$10^{5}$ = ____________
$10^{-3}$ = ____________

Write the equivalent scientific notation form next to the numbers on the chalkboard.

Example 1. 4.3629 * $10^{-4}$
Example 2. 4.3629 * $10^{2}$

Point out advantages of scientific notation to students. The following may be written on the chalkboard or given to students in handout form.

1. The significant digit is obvious, it is the only digit to the left of the decimal.

2. Recognizing the significant digit facilitates making quick estimates.

Be sure to discuss each of these advantages with students. Provide students with ample practice in making estimates while using scientific notation. For example, provide them with the following type of problem:

Estimate the product

$4.39 \bullet 10^{-4} \bullet 6.17 \bullet 10^{-5}$

Hint: $4 \bullet 6 = 24$ $-4 + -5 = -9$

Answer: estimate $= 24 \bullet 10^{-9}$

If necessary, review the rules for multiplying and dividing exponents at this time.

**SUGGESTED CLASSROOM ACTIVITIES:**

A computer uses a slightly different form of scientific notation than the traditional written form. For example, 0.000004678 would be expressed on the computer as 4.678E-6, and 4678000000 would be expressed as 4.678E9. Explain to students the form of scientific notation used on a computer. It is difficult to use subscripts or superscripts on a computer, so many computer systems use an "E" to denote an exponent.

Students should experiment with entering different numbers using direct mode on a computer. It is generally necessary to print very large or small numbers to obtain scientific notation. This is accomplished with the PRINT statement (e.g. PRINT .0000456).

Once students have had time to practice converting numbers to scientific notation using a computer in direct mode, provide them with a list of numbers to convert, print and turn in as a class assignment.

**REINFORCEMENT ACTIVITIES:**

Provide ample time for students to use drill and practice software as well as other appropriate software identified in the Software Directory section of this book.

# LESSON 13

## Numeric Trend Inference

**GRADE LEVEL:** Grades 8 to 12

**OBJECTIVE:** When presented with a list of five related numbers, students will identify the next number in the series.

**SUGGESTED INSTRUCTIONAL TIME:** Two to five 45 minute sessions

**IMPORTANT TERMS:** Numeric Inference

**BACKGROUND:** **Numeric inference** is a concept that is incorporated into many standardized tests. This lesson focuses on developing student skills for numeric inference. In addition, this lesson allows students the opportunity to develop a greater understanding of the process of controlling a microcomputer through the development of a program. The program that students will generate is relatively short, but it requires a high degree of preparation. In addition, this lesson provides an understanding of the advantage of making a flow chart.

**MATERIALS:** Chalkboard or handout with program criteria and microcomputer with programming capability.

**TEACHING INSTRUCTIONS:** Begin this lesson by explaining the process of numeric inference to students. For example, put the following numbers on the chalk board:

2, 4, _, 16

Have students identify the missing number.

Two approaches may be used to complete this lesson. As a first option, have students enter and then execute the BASIC program provided. This will allow them the opportunity to practice numeric inference skills. If you choose this option, skip the Classroom Activities section. The second option is to allow students to develop a program on their own that can be used to help in developing numeric inference skills. This option should be used if students are familiar with BASIC programming.

**SUGGESTED CLASSROOM ACTIVITIES:** Once students understand the basic concepts of numeric inference, challenge them to write a computer program that will allow practice of numeric inference skills. Provide them with the following program criteria to guide the development of this program.

## PROGRAM CRITERIA:

1) Have the computer generate a list of six numbers (only five of which will appear on the screen).

2) The six numbers must be related to each other but will differ in a systematic fashion. For example, beginning with a number between one and one hundred, the series will either increase or decrease by a factor of ([1...9] X [1..3]). In other words, the factor must be between one and nine multiplied by a number between one and three.

3) Four possible variations may be used in developing this program. These four variations include:

    a) All six numbers may be effected by the same incrementing factor.

    b) The first three and the second three numbers may be effected by different factors.

    c) The first two and the third two numbers may be effected by one factor, while the second two are effected by a separate factor.

    d) The first, third and fifth numbers may be effected by one factor while the second and fourth are incremented by a separate factor.

4) Five of the generated numbers must be visible on the screen while the sixth will be symbolized by "[ ]".

5) The program's merit may be evaluated with regard to the following conditions:

    a) Satisfaction of the above criteria will be a minimum condition.

    b) The number of programming statements included will distinguish between alternative methods (the fewer the better).

    c) A program which includes "crash" protection will be evaluated as superior to one without such protection.

The following program is provided as an example that will satisfy the above criteria. It is only one of many ways to solve the problem and should not be considered the "correct" answer.

SAMPLE PROGRAM

```
100  REM NUMERIC INFERENCE
110  DIM DIGIT(24)
120  PRINT:RESTORE:REM RESET DATA
130  LET NUM(0)=INT(RND(1)*99+1.5):REM SET NUM 1
140  LET VAR=INT(RND(1)*3+1.5):REM SET VARIATIONS
150  DATA 1,1,1,1,1,1,1,1,2,2,1,1,1,2,1,
     2,1,2,1,1,1,2,2,2
160  FOR I=1 TO (VAR * 6):READ DIGIT(I):NEXT I
170  J = 0:FOR I = 1 TO ((VAR * 6 - 5) TO (VAR * 6)
180  J=J+1:INC(J)=DIGIT(I):REM READ VAR FORMAT
190  NEXT I
200  FOR I = 1 TO 2:REM DETERMINE DIRECTION
210  DIR(I)=INT(RND(1)*1+1.5)
220  IF DIR(I) > 1 THEN DIR(I)=-1
230  FACTI(I)=INT(RND(1)*8+1.5):REM SET 1 FACTOR
240  MFACT(I)=INT(RND(1)*2+1.5):REM SET 2 FACTOR
250  IF MFACT(I)=FACTI(I) THEN GOTO 230
260  FCTR(I)=FACTI(I)*MFACT(I)*DIR(I)
270  NEXT I:REM 200-270 DETERMINE INCREMENT
280  PRINT NUM(0);" , ";:REM OUTPUT FIRST NUMBER
290  FOR I=1 TO 6:REM OUTPUT NUMBER SERIES
300  NUM(I)=NUM(I-1)+FCTR(INC(I))
310  IF I = 6 THEN PRINT "[?]":GOTO 340
320  PRINT NUM(I);" , ";
330  NEXT I
340  PRINT:INPUT "WHAT IS THE MISSING NUMBER "  ;GUESS
350  PRINT:IF GUESS=NUM(6) THEN PRINT "RIGHT":GOTO 120
370  IF GUESS <> NUM(6) THEN PRINT "WRONG THE NUMBER =
     ";NUM(6):GOTO 120
```

The program listed above will work on a computer that uses Applesoft BASIC. If any other form of BASIC is used, consult the appropriate programming manual.

**REINFORCEMENT ACTIVITIES:**

Ask students to develop several numeric inference tests. Students can practice developing their inference skills by giving tests to each other.

# Lesson 14
# Solving Quadratic Equations

**GRADE LEVEL:** Grades 10 to 12

**OBJECTIVE:** Students will use the quadratic formula to design a computer program to solve quadratic equations.

**SUGGESTED INSTRUCTIONAL TIME:** Two 45 minute sessions

**IMPORTANT TERMS:** Quadratic Equation, Quadratic Formula

**BACKGROUND:** A variety of methods of dealing with **quadratic equations** are included in the typical mathematics curriculum. Understanding of the underlying relationships of quadratic equations is a reasonable objective for hand calculation. Once that is achieved, it is more efficient to arrive at a solution using a computational tool. The outcome of this lesson results in a computer program designed to solve quadratic equations.

**MATERIALS:** Chalkboard or Overhead Projector, Microcomputer

**TEACHING SUGGESTIONS:** On the chalkboard write the following quadratic equation.

$$ax^2 + bx + c = 0 \quad \text{(a not equal to 0)}$$

Explain to students that this equation has two variables in each of three forms, x is squared, x is also multiplied by a constant, and c is by itself.

Once students are familiar with the variables in the quadratic equation, have them solve for x. This is accomplished through the following process:

$$x^2 + (b/a)x + c/a = 0$$
$$x^2 + (b/a)x = -(c/a)$$
$$x^2 + (b/a)x + (b/2a)^2 = -c/a + (b/2a)^2$$
$$(x+b/2)^2 = (-4ac+b^2)/4a^2$$
$$x+b/2a=\text{+or-}\ \mathrm{sqrt}(b^2-4ac)/2a$$
$$x =(\ -b + \text{or} - \mathrm{sqrt}(b^2-4ac))/2a$$

**SUGGESTED CLASSROOM ACTIVITIES:** Be sure that students understand this process. It is important for students to solve for x to facilitate a greater understanding of quadratic equations.

Once students are able to solve for x by hand or with a calculator, they will have the experience necessary to appreciate the advantages of having a computer perform the steps required to solve this problem. Challenge students to use the **quadratic formula** in a computer program to solve quadratic equations.

The following computer program is one example of how to solve a quadratic equation:

```
100  REM QUADRATIC EQUATION SOLVER
110  INPUT "A= ";A
120  INPUT "B= ";B
130  INPUT "C= ";C
140  RT = SQR(ABS((B*B)-(4*A*C)))
150  FX = ((-1*B)+RT)/(2*A)
160  SX = ((-1*B)-RT)/(2*A)
170  PRINT "THE SOLUTION SET = {";FX;",";SX;"}"
180  END
```

The program listed above will work on a computer that uses Applesoft BASIC. If any other form of BASIC is used, consult the appropriate programming manual.

**REINFORCEMENT ACTIVITIES:**

Allow students to enter and run the above computer program to solve for quadratic equations. Ask them to develop a detailed explanation of the function of each programming line. Students should be able to explain the outcome of each line of the computer program in relation to solving quadratic equations. Have them bring their explanations into class. Be sure to discuss with them the operation of each line of the computer program.

For example:

> Line 100 includes the name of the program.
>
> Line 110 through line 130 allows the user to enter the value for the coefficient represented by A, B or C in the quadratic equation.
>
> Line 140 sets the variable RT equal to the portion of the quadratic equation expressed as SQRT ($6^2$ - 4AC). See solution for X under Teaching Suggestion in this Lesson.
>
> Line 150 sets the variable FX equal to -B, subtracts RT and divides by the doubled constant A.
>
> Line 160 sets the variable SX equal to -B, adds RT and divides by the doubled constant A.
>
> Line 170 prints the solution set.

# LESSON 15

# Relative Magnitude of Numbers

**GRADE LEVEL:** Grades 6 to 10

**OBJECTIVE:** When presented with a **number sentence** comparing two ratios with one of the four numbers being unknown, the student will provide an estimate of the missing number.

**SUGGESTED INSTRUCTIONAL TIME:** Two 45 minute sessions

**IMPORTANT TERMS:** Numbers Sense, Number Sentence, Manipulatives

**BACKGROUND:** **Number Sense** is important in mathematics. An intuitive perception of the relative magnitude of numbers comprises one aspect of number sense. **Manipulatives**, which can vary in magnitude as the factors change, can provide a dynamic model for appreciating relative magnitudes.

One goal of this lesson is the exercise of intuitive perception, rather than cognitive comprehension. There is no need for instruction beyond an introduction of the topic and an explanation of the process.

**MATERIALS:** Microcomputer

**TEACHING SUGGESTIONS:** Provide students with several examples of numbers which obviously differ in magnitude. For example:

17 vs. 37 Which is larger?
45 vs. 27 Which is larger?

Next, provide examples which are slightly more difficult. For example,

17.4 vs. 19.398 Which is larger?
24.39 vs. 243.9 Which is larger?

Provide examples which are significantly more difficult. For example,

17/3 vs. 39/4 Which is larger?
27/3 vs. 64/8 Which is larger?

Point out that students have more than one option in solving problems such as these. One obvious solution is to convert each fraction to a decimal equivalent, another solution is to just estimate the approximate value.

Discuss possible situations where each of the two options would be appropriate. For example, an estimation would be an appropriate first step. If each number is close to the same value, an exact calculation may be important.

**SUGGESTED CLASSROOM ACTIVITIES:**

Once students understand relative magnitudes, provide them with a handout (next page) that contains the following BASIC program and instructions for operation. Students should be allowed ample time to enter this program into the computer and use it. This exercise will help students further develop their understanding of relative magnitude.

**REINFORCEMENT ACTIVITIES:**

Provide students with a list of multiplication problems in two columns. For example:

| | |
|---|---|
| 42<br>X 3 | 22<br>X 4 ____ |
| 21<br>X 7 | 53<br>X 3 ____ |

Ask students to indicate as quickly as they can which product (left or right) is larger.

## Handout

## RELATIVE MAGNITUDE GAME

**Instructions:**

Press the space bar to begin the game. A line will appear near the center of the screen and a ratio number sentence will appear near the bottom. The line represents the ratio on the left side of the number sentence. Your task will be to enter your guess as to the unknown in the ratio on the right. Notice that when you enter your answer, another line appears below the original one. That line represents the ratio on the right using your answer. If your answer is correct, the lines should be close to the same length. Your score will appear in the lower right corner. You are to try to get as high a score as possible within five minutes.

**Program:**

```
100  REM  RATIO UNKNOWN
110  HGR:HCOLOR=3
120  A=INT(RND(1)*99+1)
130  B=INT(RND(1)*99+1)
140  IF A/B > 2 THEN GOTO 120
150  C=INT(RND(1)*99+1)
160  X=(A*C)/B
170  ULIM=INT((X+(X*.10))+.5)
180  LLIM=INT((X-(X*.10))+.5)
190  PRINT SPC(13)
195  PRINT:PRINT
200  PRINT A;"/";B;" = ";"X/";C
210  HPLOT 0,100 TO (125*(A/B)),100
220  INPUT "     ESTIMATE OF X = ";GUESS
230  HPLOT 0,150 TO (125*(GUESS/C)),150
240  IF GUESS < LLIM THEN GOTO 270
250  IF GUESS > ULIM THEN GOTO 270
260  PRINT "  WAY TO GO - CLOSE ENOUGH -PRESS RETURN":GOTO 290
270  PRINT "SORRY CORRECT EST IS BETWEEN ";LLIM;"     AND ";ULIM
280  PRINT "FOR THE RATIO ";A;"/";B;" =  X/";C;"     YOUR EST = ";GUESS
290  GET CNTU$:GOTO 110: END
```

The program listed above will work on a computer that uses Applesoft BASIC. If any other form of BASIC is used, consult the appropriate programming manual.

# PART B
# SECONDARY MATH SOFTWARE DIRECTORY

**CONCEPT:** Algebra
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Equations
**PUBLISHER:** Educational Activities
P.O. Box 392
Freeport, NY 11520
**SUGGESTED PRICE:** $59.95
**HARDWARE:** Atari; Commodore 64; TRS-80; Pet; IBM PC
**DESCRIPTION:** This software contains three separate programs providing different levels of difficulty. The first level works with random equations containing one variable and one operation. The second level provides one variable and two operations. The third level works with variables on both sides of the equation. Incorrect answers produce detailed explanations of the correct approach. Documentation and a management section for monitoring student progress are included.
**EVALUATION:** *The Mathematics Teacher*, February, 1982

**CONCEPT:** Algebra
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Algebraic Expressions
**PUBLISHER:** Educational Activities
P.O. Box 392
Freeport, NY 11520
**SUGGESTED PRICE:** $59.95
**HARDWARE:** Apple II Series; Commodore 64; TRS-80; Pet; Atari
**DESCRIPTION:** This software contains two separate programs. The first program, Rewriting Verbal Phrases as Algebraic Expressions, is an explanation of the conversion of verbal terms and phrases into algebraic expressions. The second program, Evaluating Algebraic Expressions, deals with the basic functions of the X and Y variables. Documentation and a management section for monitoring student progress are included.

## ALGEBRA

**CONCEPT:** Algebra
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Algebra Coach
**PUBLISHER:** Educational Activities
P.O. Box 392
Freeport, NY 11520
**SUGGESTED PRICE:** $89.95 or $49.95 for each disk
**HARDWARE:** Apple II Series
**DESCRIPTION:** This program consists of two separate tutorial disks, Multiplying and Factoring with Binomials and Introduction to Quadratic Equations. Each tutorial is diagnostic in nature in order to direct student progress. Throughout each program, help and review are always available. Documentation and a management section for monitoring student progress are included.

**CONCEPT:** Algebra
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Equations
**PUBLISHER:** Microcomputer Workshops Courseware
225 Westchester Ave.
Portchester, NY 10573
1-914-937-5440
**SUGGESTED PRICE:** $24.95
**HARDWARE:** Atari; Apple II Series; Commodore 64; TRS-80; Pet
**DESCRIPTION:** In this tutorial, students work with algebraic equations in the form of $ax + b = c$. Step-by-step instructions are provided as well as instant feedback to reinforce learning.
**EVALUATION:** *The Mathematics Teacher*, February, 1983; *School Microware Reviews*, Summer, 1982; *Courseware Report Card*, September, 1983; *Curriculum Review*, April, 1984

**CONCEPT:** Algebra
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Solving Quadratic Equations
**PUBLISHER:** Microcomputer Workshops Courseware
225 Westchester Ave.
Portchester, NY 10573
1-914-937-5440
**SUGGESTED PRICE:** $24.95
**HARDWARE:** Atari; Apple II Series; Commodore 64; TRS-80; Pet
**DESCRIPTION:** This is tutorial software in which students work with equations in the form of $ax^2 + bx + c = 0$. Step-by-step instructions are provided as well as instant feedback to reinforce learning.
**EVALUATION:** *Journal of Computers in Mathematics and Science Teaching*, Summer, 1985; *Courseware Report Card*, September, 1983; *Curriculum Review*, April, 1984

**CONCEPT:** Algebra
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Binomial Multiplication
**PUBLISHER:** Microcomputer Workshops Courseware
225 Westchester Ave.
Portchester, NY 10573
1-914-937-5440
**SUGGESTED PRICE:** $24.95
**HARDWARE:** Apple II Series
**DESCRIPTION:** Students work with equations in the form of $(ax + b)(cx + a)$ in this tutorial. Step-by-step instructions are provided as well as instant feedback to reinforce learning.
**EVALUATION:** *The Mathematics Teacher*, April, 1984; *Curriculum Review*, April, 1984

**CONCEPT:** Algebra
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Factoring Algebraic Expressions
**PUBLISHER:** Microcomputer Workshops Courseware
225 Westchester Ave.
Portchester, NY 10573
1-914-937-5440
**SUGGESTED PRICE:** $24.95
**HARDWARE:** Apple II Series
**DESCRIPTION:** Students work with linear and quadratic expressions. Step-by-step instructions are provided as well as instant feedback to reinforce learning.
**EVALUATION:** *Computers in Mathematics and Science Teaching*, Spring, 1986; *Curriculum Review*, April, 1984

**CONCEPT:** Algebra
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Simultaneous Linear Equations
**PUBLISHER:** Microcomputer Workshops Courseware
225 Westchester Ave.
Portchester, NY 10573
1-914-937-5440
**SUGGESTED PRICE:** $24.95
**HARDWARE:** Apple II Series
**DESCRIPTION:** This is a tutorial providing step-by-step instructions for solving and graphing linear equations. Instant feedback is provided to reinforce learning.
**EVALUATION:** *Mathematics Teacher*, April, 1984; *Curriculum Review*, April, 1984

## ALGEBRA

| | |
|---|---|
| **CONCEPT:** | Algebra |
| **LEVEL:** | Grades 9 to 12 |
| **SOFTWARE TITLE:** | Graphing Linear Functions |
| **PUBLISHER:** | Microcomputer Workshops Courseware<br>225 Westchester Ave.<br>Portchester, NY 10573<br>1-914-937-5440 |
| **SUGGESTED PRICE:** | $29.95 |
| **HARDWARE:** | Apple II Series |
| **DESCRIPTION:** | This is a software tutorial that includes step-by-step instructions for solving and graphing linear equations. Instant feedback is provided to reinforce learning. |

| | |
|---|---|
| **CONCEPT:** | Algebra |
| **LEVEL:** | Grades 9 to 12 |
| **SOFTWARE TITLE:** | Coordinate |
| **PUBLISHER:** | Microcomputer Workshops Courseware<br>225 Westchester Ave.<br>Portchester, NY 10573<br>1-914-937-5440 |
| **SUGGESTED PRICE:** | $24.95 |
| **HARDWARE:** | Apple II Series; Commodore 64; Pet |
| **DESCRIPTION:** | This tutorial program provides students with practice in plotting points. Step-by-step instructions are provided as well as instant feedback to reinforce learning. |

| | |
|---|---|
| **CONCEPT:** | Algebra |
| **LEVEL:** | Grades 9 to 12 |
| **SOFTWARE TITLE:** | Motion Problems |
| **PUBLISHER:** | Microcomputer Workshops Courseware<br>225 Westchester Ave.<br>Portchester, NY 10573<br>1-914-937-5440 |
| **SUGGESTED PRICE:** | $39.95 |
| **HARDWARE:** | Atari; Apple II Series; Commodore 64; TRS-80; Pet |
| **DESCRIPTION:** | This tutorial presents a series of problems concerning topics such as opposite directions, round trip and overtaking. Step-by-step instructions are provided as well as instant feedback to reinforce learning. |

**CONCEPT:** Algebra
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Algebra and Sets
Test Problems: Algebra, Calculus, Geometry, Statistics, Ratios, Exponents
Test Problems: Geometry, LCM, Reducing Fractions, Plotting Functions, Algebraic Fractions, Currency Conversion
**PUBLISHER:** PMI, Inc.
P.O. Box 35408
Dallas, TX 75235
1-214-252-3540
**SUGGESTED PRICE:** $30.00 for each program
**HARDWARE:** Apple II Series; Commodore 64; Pet
**DESCRIPTION:** These programs provide student tutorials comprised of practice problem sequences. Teacher support materials are included.

**CONCEPT:** Algebra
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Algebra Electronic Blackboard
**PUBLISHER:** Wadsworth Electronic Publishing Company
10 Davis Dr.
Belmont, CA 94002
**SUGGESTED PRICE:** $250.00
**HARDWARE:** Apple II Series
**DESCRIPTION:** This is a tutorial comprised of 5 disks. Topics include Cartesian Coordinates, Lines and Linear Functions, Quadratics and Polynomials, Conic Sections, and Logarithms: Exponentials and Inequalities. A user's guide is included.
**EVALUATION:** *Mathematics and Computer Education*, Winter/Fall, 1984; *Educational Technology*, April, 1984

**CONCEPT:** Algebra
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Algebra Drill and Practice I
**PUBLISHER:** Conduit Software
P.O. Box 388
Iowa City, IA 52244
**SUGGESTED PRICE:** $133.95
**HARDWARE:** Apple II Series
**DESCRIPTION:** This software provides an unlimited number of sample problems. Topics included are Algebraic Signs, Simplifying Expressions, Operations with Algebraic Fractions, and Word Problems. An instructor's manual is included.
**EVALUATION:** *Mathematics and Computer Education*, Spring, 1983; *Curriculum Review*, August, 1982

## ALGEBRA

**CONCEPT:** Algebra
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Algebra Word Problems II
Algebra Word Problems III
Algebra Word Problems IV
**PUBLISHER:** Queue, Inc.
798 North Ave.
Bridgeport, CT 06606
1-800-232-2224
**SUGGESTED PRICE:** $34.95 for each program.
**HARDWARE:** Apple II Series
**DESCRIPTION:** Students are provided with practice in solving word problems covering a wide range of topics. Algebra Word Problems II presents problems in solving for unknowns in ratios, levers and see-saws, work, and the perimeter of squares and rectangles. Algebra Word Problems III includes problems solving for the area of rectangles and squares, percents, motion and numbers. Algebra Word Problems IV provides practice concerning problems involving coins, age relationships, investments and mixtures.
**EVALUATION:** *Datapro Directory of Computer Software*, November, 1985; *Mathematics Teacher*, October, 1985

**CONCEPT:** Algebra
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Classroom Algebra Contests
**PUBLISHER:** Hayden Software Co.
600 Suffolk St.
Lowell, MA 01854
1-617-937-0200
**SUGGESTED PRICE:** $79.95
**HARDWARE:** Apple II Series
**DESCRIPTION:** This software contains two modes. The Tutorial Mode covers concepts such as solving quadratic equations, Cartesian coordinates, and determining the slope and intercept of a line. In the Contest Mode, students can compete individually or in groups.

**CONCEPT:** Algebra
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Intellectual SAT Algebra
**PUBLISHER:** Queue, Inc.
798 North Ave.
Bridgeport, CT 06606
**SUGGESTED PRICE:** $79.95
**HARDWARE:** Apple II Series
**DESCRIPTION:** This program contains five lessons that teach mathematical skills needed for college entrance examination. The lessons included are Whole Numbers, Fractions and Decimals, Algebra, Ratio and Proportion, and Percent. In the Instruction Mode, a detailed solution is available for each question. The Test Mode provides further practice in applying the appropriate mathematical concepts. A manual that presents test taking techniques and a management system for analyzing student responses are included.

**CONCEPT:** Algebra
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Elementary Algebra
**PUBLISHER:** Control Data Publishing-Plato
P.O. Box 261127
San Diego, CA 92126
**SUGGESTED PRICE:** $49.95 for each program
$405.00 for a set of 9
**HARDWARE:** Apple II Series
**DESCRIPTION:** This 9 package set includes the following: Signed Number Operations; Exponents, Roots and Radicals; Polynomials; Factoring; Equations and Inequalities; Quadratic Equations; Rational Expressions; Graphing Lines on a Plane; and Systems of Equations. Each package also includes an activity guide, a diagnostic test, a mastery test and a teacher's guide.

**CONCEPT:** Algebra
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Topics in Algebra
**PUBLISHER:** H & H Publishing Company, Inc.
2165 Sunnydale
Clearwater, FL 33575
**SUGGESTED PRICE:** $50.00
**HARDWARE:** IBM PC
**DESCRIPTION:** This software consists of three interactive disks covering topics in elementary algebra. Topics included are Pre-algebra Review, Variables, Use of Parentheses, Addition of Integers and Fractions, and Linear Equations. An instruction manual is included.

## ALGEBRA

**CONCEPT:** Algebra
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Dungeons of the Algebra Dragons
**PUBLISHER:** Learning Arts
P.O. Box 179
Wichita, KS 67201
**SUGGESTED PRICE:** $24.95
**HARDWARE:** Commodore 64; Pet
**DESCRIPTION:** This software consists of five skill levels. Students must use their algebra skills in order to escape from the dragon's dungeon. A user's guide is included.

| | |
|---|---|
| **CONCEPT:** | Calculus |
| **LEVEL:** | Grades 9 to 12 |
| **SOFTWARE TITLE:** | PreCalculus Algebra |
| **PUBLISHER:** | Learning Arts<br>P.O. Box 179<br>Wichita, KS 67201 |
| **SUGGESTED PRICE:** | $69.95 for each program; $350.00 for a set of six programs |
| **HARDWARE:** | Apple II Series |
| **DESCRIPTION:** | This program, consisting of six disks, allows teachers to manipulate the curriculum to suit individual needs. Topics and titles for the six disks are Fundamental Concepts of Algebra, Equations / Inequalities, Functions, Polynomial Functions, Rational Functions and Conic Sections, Exponential and Logarithmic Functions, and Systems of Equations and Inequalities. A user's guide is included. |

| | |
|---|---|
| **CONCEPT:** | Calculus |
| **LEVEL:** | Grade 9 to 12 |
| **SOFTWARE TITLE:** | Test Problems: Factors, Interest, Statistics, Trigonometry, Calculus, Percents, Bases, Exponents<br>Test Problems: Algebra, Calculus, Geometry, Statistics, Ratios, Exponents |
| **PUBLISHER:** | PMI, Inc.<br>P.O. Box 35408<br>Dallas, TX 75235<br>1-214-252-3540 |
| **SUGGESTED PRICE:** | $30.00 for each program |
| **HARDWARE:** | Apple II Series; Commodore 64; Pet |
| **DESCRIPTION:** | Both programs are tutorials comprised of practice problem sequences. Teacher support materials are included. |

| | |
|---|---|
| **CONCEPT:** | Calculus |
| **LEVEL:** | Grades 9 to 12 |
| **SOFTWARE TITLE:** | Calculus |
| **PUBLISHER:** | Queue, Inc.<br>798 North Ave.<br>Bridgeport, CT 06606<br>1-800-232-2224 |
| **SUGGESTED PRICE:** | $34.95 |
| **HARDWARE:** | Apple II Series |
| **DESCRIPTION:** | This software consists of six programs which use a numerical approach to demonstrate derivatives. |

## CALCULUS

**CONCEPT:** Calculus
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Advanced Placement Calculus
**PUBLISHER:** Queue, Inc.
798 North Ave.
Bridgeport, CT 06606
1-800-232-2224
**SUGGESTED PRICE:** $119.95
**HARDWARE:** Apple II Series
**DESCRIPTION:** Students are provided with practice in working with test questions typically found on College Board Advanced Placement Exams. The testing procedure covers a wide variety of topics. The package also includes a management system for test analysis.

**CONCEPT:** Calculus
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** RSI Calculus
**PUBLISHER:** Queue, Inc.
798 North Ave.
Bridgeport, CT 06606
1-800-232-2224
**SUGGESTED PRICE:** $39.95
**HARDWARE:** Apple II Series
**DESCRIPTION:** This software is designed to provide drill and practice in calculus problems dealing primarily with derivatives and integrals. Algebraic, sine and cosine functions are also covered.

**CONCEPT:** Calculus
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Honors Calculus
**PUBLISHER:** Queue, Inc.
798 North Ave.
Bridgeport, CT 06606
1-800-232-2224
**SUGGESTED PRICE:** $39.95
**HARDWARE:** Apple II Series
**DESCRIPTION:** This program is designed to provide students with experience in advanced calculus problems. This program focuses upon the applications of the derivative and the definite integral.

**CONCEPT:** Calculus
**LEVEL:** Grade 9 to 12
**SOFTWARE TITLE:** Graphmaster: A Complete Graphing Utility
**PUBLISHER:** HRM Software
175 Tompkins Ave.
Pleasantville, NY 10570
**SUGGESTED PRICE:** $49.00
**HARDWARE:** Apple II Series; Commodore 64
**DESCRIPTION:** This software enables students to graph any Cartesian function or polar function. This program allows students to zero in on a particular section and to overlay a set of graphs. Graphmaster contains a calculator function for doing quick calculations. In addition to algebra, the program can also be used for teaching concepts in trigonometry, pre-calculus and calculus. A teacher's guide is included.

**CONCEPT:** Calculus
**LEVEL:** Grades 11 to 12
**SOFTWARE TITLE:** The Calculus Toolkit
**PUBLISHER:** Addison-Wesley Publishing Company
Reading, MA 01867
**SUGGESTED PRICE:** $350.00
**HARDWARE:** Apple II Series
**DESCRIPTION:** Consisting of 27 programs, this tutorial is designed to help students solve problems and understand difficult concepts. Topics included are Secant Lines, Scaler Fields, Picard's Fixed Point Method, Integration, Complex Number Calculator, Taylor Series, and Conic Sections.
**EVALUATION:** *Journal of Computers in Mathematics and Science Teaching*, Summer, 1985

# COLLEGE MATH ENTRANCE EXAMINATIONS

| | |
|---|---|
| **CONCEPT:** | College Math Entrance Examinations |
| **LEVEL:** | Grades 10 to 12 |
| **SOFTWARE TITLE:** | Quantitative Comparisons |
| **PUBLISHER:** | Charles Clark Co., Inc.<br>168 Express Drive South<br>Brentwood, NY 11717 |
| **SUGGESTED PRICE:** | $29.95 |
| **HARDWARE:** | Apple II Series; Atari |
| **DESCRIPTION:** | This is a math preparation program for students who need to take college entrance examinations similar to the SAT. A final test and comprehensive guide are included. |
| **EVALUATION:** | *Courseware Report Card*, June, 1983 |

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| **CONCEPT:** | College Math Entrance Examinations |
| **LEVEL:** | Grades 10 to 12 |
| **SOFTWARE TITLE:** | Intellectual SAT Algebra |
| **PUBLISHER:** | Queue, Inc.<br>798 North Ave.<br>Bridgeport, CT 06606<br>1-800-232-2224 |
| **SUGGESTED PRICE:** | $79.95 |
| **HARDWARE:** | Apple II Series |
| **DESCRIPTION:** | This software contains five lessons that teach mathematical skills needed for college entrance examinations. The lessons included are Whole Numbers, Fractions and Decimals, Algebra, Ratio and Proportion, and Percent. In the Instruction Mode, a detailed solution is available for each question. The Test Mode provides further practice in applying the appropriate mathematical concepts. A manual that presents test taking techniques and a management system for analyzing student responses are included. |

## COLLEGE MATH ENTRANCE EXAMINATIONS

**CONCEPT:** College Math Entrance Examinations
**LEVEL:** Grades 10 to 12
**SOFTWARE TITLE:** Intellectual SAT Geometry
**PUBLISHER:** Queue, Inc.
798 North Ave.
Bridgeport, CT 06606
1-800-232-2224
**SUGGESTED PRICE:** $79.95
**HARDWARE:** Apple II Series
**DESCRIPTION:** This program contains five lessons that teach mathematical skills needed for college entrance examinations. The lessons included are Coordinate Geometry, Angle Measure, Perimeter-Area-Volume Levels I and II, and Quantitative Comparisons. In the Instruction Mode, a detailed solution is available for each question. The Test Mode provides further practice in applying the appropriate mathematical concepts. A manual that presents test taking techniques and a management system for analyzing student responses are included.

**CONCEPT:** College Math Entrance Examinations
**LEVEL:** Grades 10 to 12
**SOFTWARE TITLE:** The Mathematics Skills Unit
**PUBLISHER:** Jostens Learning Systems, Inc.
800 E. Business Center Dr.
Mt. Prospect, Illinois 60056
**SUGGESTED PRICE:** $120.00
**HARDWARE:** Apple II Series
**DESCRIPTION:** This software consists of three disks utilizing three modes of presentation. The Test Mode simulates test conditions and provides an analysis of student performance. The Lesson Mode supplies the student with important feedback and explanations to missed questions. The Information Mode provides additional background information on test items. A teacher's guide is included.

**CONCEPT:** College Math Entrance Examinations
**LEVEL:** Grades 10 to 12
**SOFTWARE TITLE:** Advanced Placement Calculus
**PUBLISHER:** Queue, Inc.
798 North Ave.
Bridgeport, CT 06606
1-800-232-2224
**SUGGESTED PRICE:** $119.95
**HARDWARE:** Apple II Series
**DESCRIPTION:** This program is designed to provide students with practice in working with test questions typically found on College Board Advanced Placement Exams. Testing procedures cover a wide variety of topics. This package also includes a management system for test analysis.

## COLLEGE MATH ENTRANCE EXAMINATIONS

**CONCEPT:** College Math Entrance Examinations
**LEVEL:** Grades 10 to 12
**SOFTWARE TITLE:** Math Preparation Program
**PUBLISHER:** Career Aids, Inc.
20417 Nordhoff St.
Chatsworth, CA 91311
1-800-341-8200
**SUGGESTED PRICE:** $39.95
**HARDWARE:** Apple II Series; Commodore 64
**DESCRIPTION:** Consisting of three disks, this software is designed as a preparation for the SAT. The program contains a Tutor Mode that provides students with a step-by-step analysis of missed problems. An automatic timing and scoring function are built into the program.

**CONCEPT:** College Math Entrance Examinations
**LEVEL:** Grades 10 to 12
**SOFTWARE TITLE:** ACT Exam Preparation Series
**PUBLISHER:** Career Aids, Inc.
20417 Nordhoff St.
Chatsworth, CA 91311
1-800-341-8200
**SUGGESTED PRICE:** $299.95
**HARDWARE:** Apple II Series; IBM PC; TRS-80
**DESCRIPTION:** This software is designed to help students improve their scores on the ACT. The program provides unlimited drill and practice and diagnoses problem areas. Detailed explanations to incorrect responses are also include with this program.

**CONCEPT:** College Math Entrance Examinations
**LEVEL:** Grades 10 to 12
**SOFTWARE TITLE:** College Board SAT Exam Preparation Series
**PUBLISHER:** Career Aids, Inc.
20417 Nordhoff St.
Chatsworth, CA 91311
1-800-341-8200
**SUGGESTED PRICE:** $299.95
**HARDWARE:** Apple II Series; IBM PC; TRS-80
**DESCRIPTION:** In addition to the verbal section, this software contains a math section that includes 17 math tests. The program provides solutions and explanations to questions when required. From the results of the tests, the program diagnoses the weak math areas of the students and provides a tutorial directed at improving the deficient areas.

**CONCEPT:** Geometry
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Measuring with a Ruler: Perimeter, Circumference and Area
**PUBLISHER:** Educational Activities
P.O. Box 392
Freeport, NY 11520
**SUGGESTED PRICE:** $59.95
**HARDWARE:** Apple II Series; Commodore 64; TRS-80; IBM PC
**DESCRIPTION:** This tutorial teaches basic principles of measurement. Students learn concepts of perimeter, circumference and area. These concepts are applied by finding the perimeter and area of different shaped polygons, rectangles and triangles. The circumference and area of a circle are also presented. Quizzes are included as well as documentation and a management system for monitoring student progress.

**CONCEPT:** Geometry
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Fundamentals of Geometry
**PUBLISHER:** Educational Activities
P.O. Box 392
Freeport, NY 11520
**SUGGESTED PRICE:** $59.95
**HARDWARE:** Apple II Series; IBM PC
**DESCRIPTION:** This tutorial presents basic geometric concepts, forms and terms. Students experiment with various angles and quadrilaterals to produce rectangles, squares, rhombi and trapezoids. Incorrect answers branch students to detailed explanations. Also included are documentation and a management system for monitoring students progress.

**CONCEPT:** Geometry
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Areas of Triangles and Quadrilaterals
**PUBLISHER:** Educational Activities
P.O. Box 392
Freeport, NY 11520
**SUGGESTED PRICE:** $59.95
**HARDWARE:** Apple II Series; IBM PC
**DESCRIPTION:** This program is a tutorial that works with finding the area for a variety of three and four sided figures. A review section provides problems by means of a random problem generator. Documentation and a management system for monitoring student progress are included.

## GEOMETRY

**CONCEPT:** Geometry
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Circles
**PUBLISHER:** Educational Activities
P.O. Box 392
Freeport, NY 11520
**SUGGESTED PRICE:** $59.95
**HARDWARE:** Apple II Series; IBM PC
**DESCRIPTION:** This is a detailed tutorial that includes a variety of definitions and concepts such as radii, diameter, circumference, lines, angles, secants, tangents and Pi. Students work with formulas to find the circumference and area of circles. A review section presents randomly generated problems. Also included are documentation and a management system for monitoring students progress.

**CONCEPT:** Geometry
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Areas and Volumes
Test Problems: Algebra, Calculus, Geometry, Statistics, Ratios, Exponents
Test Problems: Geometry, LCM, Reducing Fractions, Plotting Functions, Algebraic Fractions, Currency Conversion
**PUBLISHER:** PMI, Inc.
P.O. Box 35408
Dallas, TX 75235
1-214-252-2540
**SUGGESTED PRICE:** $30.00 for each program
**HARDWARE:** Apple II Series; Commodore 64; Pet
**DESCRIPTION:** These programs are comprised of practice problem sequences. Teacher support materials are included.

**CONCEPT:** Geometry
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** The Factory
**PUBLISHER:** Sunburst Communications
39 Washington Ave.
Pleasantville, NY 10570-9971
**SUGGESTED PRICE:** $59.00
**HARDWARE:** Apple II Series; Atari; Commodore 64; IBM PC; TRS-80; Tandy 1000
**DESCRIPTION:** Student skills in visual discrimination, spatial perception, logic, and sequence are developed by using geometric designs. Students are challenged to create geometric products on an assembly line. Problem solving strategies include analysis of a process, working backwards and determining sequences.
**EVALUATION:** *Computers in the Schools*, Spring, 1985; *Classroom Computer Learning*, October, 1985; *Courseware Report Card*, June, 1983

**CONCEPT:** Geometry
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** The Geometric Supposer: TRIANGLES
**PUBLISHER:** Sunburst Communications
39 Washington Ave.
Pleasantville, NY 10570-9971
**SUGGESTED PRICE:** $99.00
**HARDWARE:** Apple II Series
**DESCRIPTION:** This program teaches the properties of triangles such as segments, medians, altitudes, parallel lines, angle bisectors and perpendicular bisectors. Students experiment with triangle construction and apply the procedures for the constructions with other types of triangles. The program also allows students to make measurements and to change the scale.
**EVALUATION:** *The Computing Teacher*, June, 1986

**CONCEPT:** Geometry
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** The Geometric Supposer: QUADRILATERALS
**PUBLISHER:** Sunburst Communications
39 Washington Ave.
Pleasantville, NY 10570-9971
**SUGGESTED PRICE:** $99.00
**HARDWARE:** Apple II Series
**DESCRIPTION:** This software allows student to experiment with constructions on quadrilaterals and develop theorems. Students make quadrilateral constructions and apply the procedures used to other types of quadrilaterals. This program also allows students to make measurements and to change scale.

## GEOMETRY

**CONCEPT:** Geometry
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Intellectual SAT Geometry
**PUBLISHER:** Queue, Inc.
798 North Ave.
Bridgeport, CT 06606
1-800-232-2224
**SUGGESTED PRICE:** $79.95
**HARDWARE:** Apple II Series
**DESCRIPTION:** This program contains five lessons that teach mathematical skills needed for college entrance examinations. Lessons included are Coordinate Geometry; Angle Measure; Perimeter-Area-Volume Levels I and II; and Quantitative Comparisons. In the Instruction Mode, a detailed solution is available for each question. Test Mode provides further practice in applying the appropriate mathematical concepts. A manual that presents test taking techniques and a management system for analyzing student responses are included.

**CONCEPT:** Geometry
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Geometry with Parallel Lines
**PUBLISHER:** Queue, Inc.
798 North Ave.
Bridgeport, CT 06606
1-800-232-2224
**SUGGESTED PRICE:** $39.95
**HARDWARE:** Apple II Series
**DESCRIPTION:** This software displays a graphic that contains a triangle or two parallel lines dissected by an angular line. Each display includes the degrees for some of the angles. Students must apply geometric theorems to determine the degrees in the unknown angles.

**CONCEPT:** Geometry
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** High School Math Competency
**PUBLISHER:** Learning Arts
P.O. Box 179
Wichita, Kansas 67201
**SUGGESTED PRICE:** $99.99
**HARDWARE:** TRS-80
**DESCRIPTION:** This is a drill and remediation program in basic mathematics designed for high school students. The topics included are Whole numbers, Fractions, Decimals, Basic Percent, Primes and Factors, Integers, Algebra, Geometry, Ratio and Proportion, Probability, Statistics, Percent, Word Problems, Money Problems, and Miscellaneous Problems.

**CONCEPT:** Geometry
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Geometry Volume I: Basic Geometrical Notions
**PUBLISHER:** Prentice-Hall, Inc.
P.O. Box 500
Englewood Cliffs, NY 07632
1-210-592-2000
**SUGGESTED PRICE:** $39.95
**HARDWARE:** Apple II Series; Commodore 64; IBM PC
**DESCRIPTION:** This program includes instruction in four fundamental areas: measurement (angles, lines, area, and volume); the basic concepts of geometry (postulates, lines, rays, and angles); relations (congruity and similarity); and transformations (translation, reflection, rotation, and symmetry).

**CONCEPT:** Geometry
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Geometry Volume II: Introduction to Plane and Space Geometry
**PUBLISHER:** Prentice-Hall, Inc
P.O. Box 500
Englewood Cliffs, NY 07632
1-201-592-2000
**SUGGESTED PRICE:** $39.95
**HARDWARE:** Apple II Series; Commodore 64; IBM PC
**DESCRIPTION:** This software includes geometric concepts for figures such as circles, triangles, polygons and quadrilaterals.

**CONCEPT:** Geometry
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Trap-a-Zoid
**PUBLISHER:** Opportunities for Learning, Inc.
20417 Nordhoff St.
Chatsworth, CA 91311
1-818-341-2535
**SUGGESTED PRICE:** $39.95
**HARDWARE:** Apple II Series; IBM PC; Commodore 64
**DESCRIPTION:** This is a mathematical game that develops skills in geometry. Students must prevent alien creatures (Zoids) from escaping shapes such as triangles, squares, and polygons by plotting points. The program includes five levels of play.
**EVALUATION:** *EPIE*

## GEOMETRY

**CONCEPT:** Geometry
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Geo-Pool & Geo-Billiards
**PUBLISHER:** Opportunities for Learning, Inc.
20417 Nordhoff St.
Chatsworth, CA 91311
1-818-341-2535
**SUGGESTED PRICE:** $39.95
**HARDWARE:** Apple II Series
**DESCRIPTION:** This program is in a game format that develops skill in estimating angles. Students score points in Geo-Pool by estimating the angle needed to hit one of the balls into the corner pocket. In Geo-Billiards, students score points by estimating the number of cushions before the shot.

**CONCEPT:** Geometry
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Mathematics Volume 3 - Geometry
**PUBLISHER:** Minnesota Educational Computing Corporation (MECC)
3490 Lexington Ave. North
St. Paul, MN 55112
1-612-481-3500
**SUGGESTED PRICE:** $45.00
**HARDWARE:** Apple II Series
**DESCRIPTION:** This software is designed to serve as an introduction to geometry. The program is divided into five lessons. The first lesson provides practice in identifying polygons. Other lessons focus upon the calculation of perimeter and area for various geometric shapes.

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| **CONCEPT:** | Graphing |
| **LEVEL:** | Grades 9 to 12 |
| **SOFTWARE TITLE:** | Graphing Linear Equations |
| **PUBLISHER:** | Educational Activities<br>P.O. Box 392<br>Freeport, NY 11520 |
| **SUGGESTED PRICE:** | $149.95 |
| **HARDWARE:** | Apple II Series; TRS-80; Atari; Commodore 64; Pet |
| **DESCRIPTION:** | This software consists of two programs. The first program, Introduction to Graphing on the Coordinate Plane, requires students to determine the X and Y coordinates from the graphic display on the monitor. The second program, Plotting Points on the Coordinate Plane, provides practice in plotting random ordered pairs on the screen by moving the cursor to the correct positions. Documentation is included. |

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| **CONCEPT:** | Graphing |
| **LEVEL:** | Grades 9 to 12 |
| **SOFTWARE TITLE:** | Graphing |
| **PUBLISHER:** | Educational Activities<br>P.O. Box 392<br>Freeport, NY 11520 |
| **SUGGESTED PRICE:** | $59.95 |
| **HARDWARE:** | Apple II Series |
| **DESCRIPTION:** | This consists of four program disks which include Solving Equations with Two Unknowns, The Solutions Method, The Intercepts Method and The Slope-Intercept Method. Each tutorial provides drill and practice exercises by utilizing randomly generated equations in the form of $y = mx + b$ and $Ax + By = C$. Documentation and a management system to monitor student progress are included. |

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| **CONCEPT:** | Graphing |
| **LEVEL:** | Grades 9 to 12 |
| **SOFTWARE TITLE:** | Linear Function and Graph I |
| **PUBLISHER:** | Queue, Inc.<br>798 North Ave.<br>Bridgeport, CT 06606<br>1-800-232-2224 |
| **SUGGESTED PRICE:** | $39.95 |
| **HARDWARE:** | Apple II Series |
| **DESCRIPTION:** | Students are taught how to use the equation ($y = mx + b$) to graph a line in which m is the slope and b is the intercept. A linear graph is used to display the relationship of X and Y. |

## GRAPHING

**CONCEPT:** Graphing
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Linear Function and Graph II
**PUBLISHER:** Queue, Inc.
798 North Ave.
Bridgeport, CT 06606
1-800-232-2224
**SUGGESTED PRICE:** $39.95
**HARDWARE:** Apple II Series
**DESCRIPTION:** This software presents a graph and problem in two parts. The first part of the problem requires students to solve a simultaneous equation to find the values for X and Y. The second part of the problem displays the same formulas as inequalities on a graph. Students are required to find where the equalities occur on the graph.

**CONCEPT:** Graphing
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Graphs of Lines and Hyperbola
**PUBLISHER:** Queue, Inc.
798 North Ave.
Bridgeport, CT 06606
1-800-232-2224
**SUGGESTED PRICE:** $39.95
**HARDWARE:** Apple II Series
**DESCRIPTION:** This program contains two parts, Lines (line equations) and Hyperbola (quadratic equations). Each problem produces a randomly generated graph with six formulas. Students must choose the formula that corresponds with displayed graph.

**CONCEPT:** Graphing
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Green Globs and Graphing Equations
**PUBLISHER:** Sunburst Communications
39 Washington Ave.
Pleasantville, NY 10570-9971
**SUGGESTED PRICE:** $59.00
**HARDWARE:** Apple II Series; IBM PC
**DESCRIPTION:** This software utilizes four activities to teach graphing. The Equation Plotter provides students with practice in graphing general functions. In Linear and Quadratic Graphs and Tracker, students write equations for computer generated graphs. Green Globs is a game that requires students to write equations for graphs that cover a series of green globs on the grid. A teacher's guide is included.

**CONCEPT:** Graphing
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Interpreting Graphs
**PUBLISHER:** Sunburst Communications
39 Washington Ave.
Pleasantville, NY 10570-9971
**SUGGESTED PRICE:** $59.00
**HARDWARE:** Apple II Series; IBM PC
**DESCRIPTION:** This software consists of two programs. Relating Graphs to Events, the first program, teaches students how real events are represented on a graph. Functional relationships are stressed rather than numeric values. Escape, the second program, is a game in which students are required to block escaping bank robbers by supplying appropriate grid coordinates. A teacher's guide is included.

**CONCEPT:** Graphing
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Mathgrapher
**PUBLISHER:** HRM Software
175 Tompkins Ave.
Pleasantville, NY 10570
**SUGGESTED PRICE:** $69.00
**HARDWARE:** Apple II Series; Commodore 64
**DESCRIPTION:** This software is designed to teach graphing concepts and the properties of functions at different levels of difficulty. This program allows students to solve algebra, trigonometry and calculus problems. Program options include the ability to overlay several graphs at one time, to graph polar or Cartesian functions, and to determine the slope from any point. A teaching guide is included.

**CONCEPT:** Graphing
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Micrographing
**PUBLISHER:** Charles Clark Co., Inc.
168 Express Drive South
Brentwood, NY 11717
**SUGGESTED PRICE:** $50.00
**HARDWARE:** Apple II Series; Commodore 64
**DESCRIPTION:** This program is designed to enable students to draw graphs of curve functions, polar curves, parametric curves and simultaneous equations. The program provides the option of changing parameters which allows students to view the total curve or zoom in on a particular section of the curve. Curves can also be drawn by plotting a series of points. A teacher's guide is included.

# GRAPHING

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| **CONCEPT:** | Graphing |
| **LEVEL:** | Grades 9 to 12 |
| **SOFTWARE TITLE:** | Graphmaster: A Complete Graphing Utility |
| **PUBLISHER:** | HRM Software<br>175 Tompkins Ave.<br>Pleasantville, NY 10570 |
| **SUGGESTED PRICE:** | $49.00 |
| **HARDWARE:** | Apple II Series; Commodore 64 |
| **DESCRIPTION:** | Students are enabled to graph any Cartesian function or polar function, to zero in on a particular section and to overlay a set of graphs. The program contains a calculator function for doing quick calculations. In addition to algebra, the program can also be used for teaching concepts in trigonometry, pre-calculus, and calculus. A teacher's guide is included. |

**CONCEPT:** Logarithms
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Numbers, Logs, Antilogs
**PUBLISHER:** PMI, Inc.
P.O. Box 35408
Dallas, TX 75235
1-214-252-3540
**SUGGESTED PRICE:** $30.00
**HARDWARE:** Apple II Series; Commodore 64; Pet
**DESCRIPTION:** This is a tutorial comprised of practice problem sequences. Teacher support materials are included.

**CONCEPT:** Logarithms
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** PreCalculus Algebra
**PUBLISHER:** Learning Arts
P.O. Box 179
Wichita, KS 67201
**SUGGESTED PRICE:** $69.95 for each program; $350.00 for set of six programs
**HARDWARE:** Apple II Series
**DESCRIPTION:** This program consists of six disks. This program allows the teacher to manipulate the curriculum to suit individual needs. Titles for the six disks are Exponential and Logarithmic Functions; Fundamental Concepts of Algebra; Equations / Inequalities; Functions, Polynomial Functions, Rational Functions and Conic Sections, and Systems of Equations and Inequalities. A user's guide is included.

**CONCEPT:** Logarithms
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Algebra III Volume 2: Matrices and Complex Numbers
**PUBLISHER:** Prentice-Hall, Inc.
P.O. Box 500
Englewood Cliffs, NY 07632
1-201-592-2000
**SUGGESTED PRICE:** $39.95
**HARDWARE:** Apple II Series; Commodore 64; IBM PC
**DESCRIPTION:** This software covers a series of topics such as: Logarithms, Operations with Matrices, Complex Numbers, Polynomial Functions, and Arithmetic and Geometric Sequences of Real Numbers.

## LOGARITHMS

**CONCEPT:** Logarithms
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Exponential and Logarithmic Functions
**PUBLISHER:** Queue, Inc.
798 North Ave.
Bridgeport, CT 06606
1-800-232-2224
**SUGGESTED PRICE:** $34.95
**HARDWARE:** Apple II Series
**DESCRIPTION:** This software is designed as an introduction for students to the properties of logarithmic functions and the relationship of exponential functions and graphs. Students investigate the rates of change in graphs involving exponential functions.

**CONCEPT:** Math Games
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** COMP-U-SOLVE: An Adventure in Problem Solving
**PUBLISHER:** Educational Activities
P.O. Box 392
Freeport, NY 11520
**SUGGESTED PRICE:** $59.95 for each disk; $109.00 for both disks
**HARDWARE:** Apple II Series; TRS-80; Commodore 64
**DESCRIPTION:** This is a software package of two disks containing classical puzzles that are graded from easiest to hardest. Each disk contains five programs or games, and each program has two levels. The Regular Mode helps students by giving hints and general guidelines. The Contest Mode, on the other hand, provides no feedback. Also included are documentation and a management system for monitoring student progress.

**CONCEPT:** Math Games
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Factor Blast
**PUBLISHER:** Micromedia
172 Broadway
Woodcliffe Lake, NY 07675
**SUGGESTED PRICE:** $34.95
**HARDWARE:** Atari; Apple II Series
**DESCRIPTION:** This program tests the knowledge of students concerning factors and prime numbers in a game format. It utilizes animation and sound for added interest.

**CONCEPT:** Math Games
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Classroom Algebra Contests
**PUBLISHER:** Micromedia
172 Broadway
Woodcliffe Lake, NY 07675
**SUGGESTED PRICE:** $79.95
**HARDWARE:** Apple II Series
**DESCRIPTION:** This software contains 2 modes. The Tutorial Mode covers concepts such as Solving Quadratic Equations, Cartesian Coordinates, and Determining the Slope and Intercept of a Line. In the Contest Mode, students can compete individually or in groups.

## MATH GAMES

**CONCEPT:** Math Games
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** The King's Rule
**PUBLISHER:** Sunburst Communications
39 Washington Ave.
Pleasantville, NY 10570-9971
**SUGGESTED PRICE:** $59.00
**HARDWARE:** Apple II Series; Commodore 64; IBM PC; TRS-80; Tandy 1000
**DESCRIPTION:** This is a game format program that requires students to generate and test hypotheses. In order to proceed through the king's castle, students must determine numerical rules. The program includes 6 levels of problem solving difficulty.
**EVALUATION:** *Computers in Mathematics and Science Teaching*, Fall, 1984;
*Mathematics Teacher*, October, 1985
*EPIE*

**CONCEPT:** Math Games
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Hot Dog Stand
**PUBLISHER:** Sunburst Communications
39 Washington Ave.
Pleasantville, NY 10570-9971
**SUGGESTED PRICE:** $59.00
**HARDWARE:** IBM PC; TRS-80; Tandy 1000
**DESCRIPTION:** Practice in general mathematical skills is provided by having students run a simulated hot dog stand. Students work with calculating and estimating whole numbers, decimals and fractions. During the simulation, students must make a series of practical decisions concerning the operation of the hot dog stand.

**CONCEPT:** Math Games
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Interpreting Graphs
**PUBLISHER:** Sunburst Communications
39 Washington Ave.
Pleasantville, NY 10570-9971
**SUGGESTED PRICE:** $59.00
**HARDWARE:** Apple II Series; IBM PC
**DESCRIPTION:** This software consists of two programs. **Relating Graphs to Events**, the first program, teaches students how real events are represented on a graph. Functional relationships are stressed rather than numeric values. **Escape**, the second program, is a game in which students are required to block escaping bank robbers by supplying appropriate grid coordinates. A teacher's guide is included.

**CONCEPT:** Math Games
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Puzzles and Problem Solving: Algebra
**PUBLISHER:** Learning Arts
P.O. Box 179
Wichita, KS 67201
**SUGGESTED PRICE:** $49.00
**HARDWARE:** TRS-80
**DESCRIPTION:** This software contains puzzles and problems covering a variety of skill levels. Easier levels introduce students to algebraic expressions. More difficult levels require students to solve problems by working backwards. Puzzles involve determining the correct algebraic formula to match a series of chosen numbers.

**CONCEPT:** Math Games
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Dungeons of the Algebra Dragons
**PUBLISHER:** Learning Arts
P.O. Box 179
Wichita, KS 67201
**SUGGESTED PRICE:** $24.95
**HARDWARE:** Commodore 64; Pet
**DESCRIPTION:** This program consists of five skill levels. Students must use their algebraic skills in order to escape from the dragon's dungeon. A user's guide is included.

**CONCEPT:** Math Games
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Guess My Rule
**PUBLISHER:** HRM Software
175 Tompkins Ave.
Pleasantville, NY 10570
**SUGGESTED PRICE:** $59.00
**HARDWARE:** Apple II Series
**DESCRIPTION:** Students are challenged to determine rules or algorithms stored by a computer. Students enter numerical data and the result is displayed by the computer. They can add new rules to the list to provide challenges to other students. This program can be adjusted to fit the mathematical background of students. A teaching guide is included.

## MATH GAMES

**CONCEPT:** Math Games
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Algebra Arcade
**PUBLISHER:** Wadsworth Electronic Publishing Company
10 Davis Dr.
Belmont, CA 94002
**SUGGESTED PRICE:** $49.95
**HARDWARE:** Apple II Series; Commodore 64; IBM PC
**DESCRIPTION:** This program teaches algebra and trigonometry in a game format. In order to score points, students must enter an algebraic equation which produces a graph that destroys Algebroids. Options include the number of players, time limits, and types of equations. A teacher's guide is included.
**EVALUATION:** *Mathematics and Computer Education*, Spring, 1984; *Mathematics Teacher*, May, 1984

**CONCEPT:** Math Games
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Trigs in Space: Using Radians and Degrees
**PUBLISHER:** HRM Software
175 Tompkins Ave.
Pleasantville, NY 10570
**SUGGESTED PRICE:** $49.00
**HARDWARE:** Apple II Series; Commodore 64
**DESCRIPTION:** Students are taught radian measurement in a game format. In order to destroy approaching enemy spacecraft, students must rotate the spaceship to the correct position and fire. Position is determined by using radar reports and trigonometric relations of angles.

**CONCEPT:** Math Games
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Algebra Billiards
**PUBLISHER:** Opportunities for Learning, Inc.
20417 Nordhoff St.
Chatsworth, CA 91311
1-818-341-2535
**SUGGESTED PRICE:** $24.95
**HARDWARE:** Apple II Series; IBM PC; TRS-80
**DESCRIPTION:** This program presents instruction in algebra in a game format. Using the game of pool for the game format, students must answer drill and practice questions. If a question is answered incorrectly, the program branches students to a tutorial that will improve performance.

**CONCEPT:** Math Games
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Trap-a-Zoid
**PUBLISHER:** Opportunities for Learning, Inc.
20417 Nordhoff St.
Chatsworth, CA 91311
1-818-341-2535
**SUGGESTED PRICE:** $39.95
**HARDWARE:** Apple II Series; IBM PC; Commodore 64
**DESCRIPTION:** This mathematical game develops skills in geometry. Students must prevent alien creatures (Zoids) from escaping shapes such as triangles, squares and polygons by plotting points. This program includes five levels of play.

**CONCEPT:** Math Games
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Geo-Pool & Geo-Billiards
**PUBLISHER:** Opportunities for Learning, Inc.
20417 Nordhoff St.
Chatsworth, CA 91311
1-818-341-2535
**SUGGESTED PRICE:** $39.95
**HARDWARE:** Apple II Series
**DESCRIPTION:** This fun program develops skill in estimating angles. Students score points in Geo-Pool by estimating the angle needed to hit one of the balls into the corner pocket. In Geo-Billiards, students score points by estimating the number of cushions before the shot.

## BASIC MATH SKILLS

**CONCEPT:** Basic Math Skills
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Rounding Off Numbers
**PUBLISHER:** Educational Activities
P.O. Box 392
Freeport, NY 11520
**SUGGESTED PRICE:** $59.95
**HARDWARE:** Apple II Series; Commodore 64; TRS-80; IBM PC
**DESCRIPTION:** This tutorial teaches rounding for whole numbers, decimals and mixed numbers. Place values of ten thousandths to ten thousands are incorporated into the tutorial. Quizzes are given at each level of difficulty. Also included are documentation and a management system for monitoring student progress.
**EVALUATION:** *InfoWorld*, November 23, 1981

**CONCEPT:** Basic Math Skills
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Whole Numbers: Addition, Subtraction, Multiplication, Division
**PUBLISHER:** Educational Activities
P.O. Box 392
Freeport, NY 11520
**SUGGESTED PRICE:** $59.95
**HARDWARE:** Apple II Series; Commodore 64; TRS-80; IBM PC
**DESCRIPTION:** This program is a tutorial that presents three levels of difficulty. The hard level in addition and all levels of multiplication include carrying. The hard level for subtraction requires borrowing. Quizzes are given at each level of difficulty. Also included are documentation and a management system for monitoring student progress.

**CONCEPT:** Basic Math Skills
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Fractions: Addition and Subtraction
**PUBLISHER:** Educational Activities
P.O. Box 392
Freeport, NY 11520
**SUGGESTED PRICE:** $59.95
**HARDWARE:** Apple II Series; Commodore 64; TRS-80; IBM PC
**DESCRIPTION:** This tutorial presents two levels of difficulty. Easy levels include addition and subtraction of fractions with uncommon denominators. Hard levels teach addition and subtraction of mixed numbers. Quizzes are given at each level of difficulty. Also included are documentation and a management system for monitoring student progress.

**CONCEPT:** Basic Math Skills
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Fractions: Multiplication and Division
**PUBLISHER:** Educational Activities
P.O. Box 392
Freeport, NY 11520
**SUGGESTED PRICE:** $59.95
**HARDWARE:** Apple II Series; Commodore 64; TRS-80; IBM PC
**DESCRIPTION:** This program presents two levels of difficulty. Easy levels deal with pure fractions, whereas hard levels deal with mixed numbers. Quizzes are given at each level of difficulty. Documentation and a management system for monitoring student progress are included.

**CONCEPT:** Basic Math Skills
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Decimals: Addition, Subtraction, Multiplication, Division
**PUBLISHER:** Educational Activities
P.O. Box 392
Freeport, NY 11520
**SUGGESTED PRICE:** $59.95
**HARDWARE:** Apple II Series; Commodore 64; TRS-80; IBM PC
**DESCRIPTION:** This presents two levels of difficulty. Pure decimals are taught in the easy levels, whereas both pure and mixed decimals are presented in hard levels. Quizzes are given at each level of difficulty. Also included are documentation and a management system for monitoring student progress.

**CONCEPT:** Basic Math Skills
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Graphs: Means, Median and Mode
**PUBLISHER:** Educational Activities
P.O. Box 392
Freeport, NY 11520
**SUGGESTED PRICE:** $59.95
**HARDWARE:** Apple II Series; Commodore 64; TRS-80; IBM PC
**DESCRIPTION:** This is a tutorial that teaches the fundamentals for reading graphs. Emphasis is placed on finding and comparing the mean, median and mode. Quizzes are included as well as documentation and a management system for monitoring student progress.

## BASIC MATH SKILLS

**CONCEPT:** Basic Math Skills
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Converting Fractions and Percents: Problems with Percents
**PUBLISHER:** Educational Activities
P.O. Box 392
Freeport, NY 11520
**SUGGESTED PRICE:** $59.95
**HARDWARE:** Apple II Series; Commodore 64; TRS-80; IBM PC
**DESCRIPTION:** This tutorial program teaches conversion of fractions to percents and percents to fractions. A lesson is also included that teaches students how to set up proportions. Quizzes are included as well as documentation and a management system for monitoring student progress.
**EVALUATION:** *InfoWorld*, November 23, 1981

**CONCEPT:** Basic Math Skills
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Measuring with a Ruler: Perimeter, Circumference and Area
**PUBLISHER:** Educational Activities
P.O. Box 392
Freeport, NY 11520
**SUGGESTED PRICE:** $59.95
**HARDWARE:** Apple II Series; Commodore 64; TRS-80; IBM PC
**DESCRIPTION:** This software is a tutorial that teaches the basic principles of measurement. Students learn the concepts of perimeter, circumference and area. These concepts are applied by finding the perimeter and area of different shaped polygons, rectangles and triangles. Circumference and area of a circle are also presented. Quizzes are included as well as documentation and a management system for monitoring student progress.

**CONCEPT:** Basic Math Skills
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Arithmetic Doctor
**PUBLISHER:** Educational Activities
P.O. Box 392
Freeport, NY 11520
**SUGGESTED PRICE:** $129.00
**HARDWARE:** Apple II Series
**DESCRIPTION:** This software consists of four disks that provide diagnosis, practice and remediation in addition, subtraction, multiplication and division. Each arithmetic operation contains 19 different levels except for multiplication which has 17 levels. A mastery level of 70% must be reached before students advance to the next level. Included are documentation and a management system for monitoring student progress.

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| **CONCEPT:** | Basic Math Skills |
| **LEVEL:** | Grades 9 to 12 |
| **SOFTWARE TITLE:** | Math for Everyday Living |
| **PUBLISHER:** | Educational Activities<br>P.O. Box 392<br>Freeport, NY 11520 |
| **SUGGESTED PRICE:** | $99.00 |
| **HARDWARE:** | Apple II Series; Commodore 64; Pet |
| **DESCRIPTION:** | This tutorial emphasizes real life math and business problems. Topics include Working with Sales Slips, Unit Pricing, Saving on Transportation (Advanced Division), Sales Tax, and Net Pay. A diagnostic placement option and management system for monitoring student progress are included. |

| | |
|---|---|
| **CONCEPT:** | Basic Math Skills |
| **LEVEL:** | Grades 9 to 12 |
| **SOFTWARE TITLE:** | High School Math Competency |
| **PUBLISHER:** | Learning Arts<br>P.O. Box 179<br>Wichita, KS 67201 |
| **SUGGESTED PRICE:** | $99.99 |
| **HARDWARE:** | Apple II Series; TRS-80 |
| **DESCRIPTION:** | This is a drill and remediation program in basic mathematics designed for high school students. The topics included are Whole Numbers, Fractions, Decimals, Basic Percent, Primes and Factors, Integers, Algebra, Geometry, Ratio and Proportion, Probability, Statistics, Percent, Word Problems, Money Problems, and Miscellaneous Problems. |

| | |
|---|---|
| **CONCEPT:** | Basic Math Skills |
| **LEVEL:** | Grades 9 to 12 |
| **SOFTWARE TITLE:** | More Powers to You: Exponents and Scientific Notation |
| **PUBLISHER:** | MicroLab<br>5725 Dragon Way<br>Cincinnati, OH 45227<br>1-513-561-7671 |
| **SUGGESTED PRICE:** | $35.00 |
| **HARDWARE:** | Apple II Series; Commodore 64; IBM PC |
| **DESCRIPTION:** | This program is a tutorial that teaches the fundamental concepts of exponents and scientific notation. A test mode scores students comprehension of major concepts. Students also practice multiplying and dividing in scientific notation. A manual containing work sheets, tests, and puzzles is included. |
| **EVALUATION:** | *Journals of Computers in Mathematics and Science Teaching*, Winter, 1985/86 |

## PROBLEM SOLVING

**CONCEPT:** Problem Solving
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Ratio and Proportion
**PUBLISHER:** Educational Activities
P.O. Box 392
Freeport, NY 11520
**SUGGESTED PRICE:** $59.95
**HARDWARE:** Apple II Series
**DESCRIPTION:** These five tutorial programs include Introduction to Ratios, Two Ways to Write Ratios, Writing Equivalent Ratios, Introducing Proportions and Using Cross Products. Each tutorial utilizes a diagnostic approach by examining student response and branching students to an appropriate section within the tutorial. Also included are a random word problem generator for the proportion programs and two quiz programs.

**CONCEPT:** Problem Solving
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** COMP-U-SOLVE: An Adventure in Problem Solving
**PUBLISHER:** Educational Activities
P.O. Box 392
Freeport, NY 11520
**SUGGESTED PRICE:** $109.00
**HARDWARE:** Apple II Series; TRS-80; Commodore 64
**DESCRIPTION:** This is a software package consisting of two disks containing classical puzzles that are graded from easiest to hardest. Each disk contains five programs or games, and each program has two levels. Regular Mode helps students by giving hints and general guidelines. Contest Mode, on the other hand, provides no feedback. Each disk can be purchased separately for $59.95. Also included are documentation and a management system for monitoring student progress.

**CONCEPT:** Problem Solving
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** SemCalc: The Word Problem Solver
**PUBLISHER:** Sunburst Communications
39 Washington Ave.
Pleasantville, New York 10570-9971
**SUGGESTED PRICE:** $95.00
**HARDWARE:** Apple II Series; Atari; TRS-80
**DESCRIPTION:** This is a tutorial developed to induce students to think of units rather than numbers when solving word problems. The program has been correlated for use with 27 text books. A teacher's guide is included.
**EVALUATION:** *EPIE*

**CONCEPT:** Problem Solving
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Algebra Word Problems I: Motion
Algebra Word Problems II: Area, Perimeter, and Lever
Algebra Word Problems III: Mixture, Coin, and Investment
**PUBLISHER:** Microcomputer Workshops Courseware
225 Westchester Ave.
Port Chester, NY 10573
1-914-937-5440
**SUGGESTED PRICE:** $39.95 for each program; $105.00 for all three programs
**HARDWARE:** Apple II Series
**DESCRIPTION:** These programs are designed to provide practice in solving randomly generated word problems. Students progress through each problem in a step-by-step manner and receive explanations for incorrect answers.

**CONCEPT:** Problem Solving
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Algebra Drill and Practice I
**PUBLISHER:** Conduit Software
P.O. Box 388
Iowa City, IA 52244
**SUGGESTED PRICE:** $133.95
**HARDWARE:** Apple II Series
**DESCRIPTION:** This software provides many sample problems. Topics included are Word Problems, Algebraic Signs, Simplifying Expressions and Operations with Algebraic Fractions. An instructor's manual is included.
**EVALUATION:** *Curriculum Review*, August, 1982

**CONCEPT:** Problem Solving
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** The King's Rule
**PUBLISHER:** Sunburst Communications
39 Washington Ave.
Pleasantville, NY 10570-9971
**SUGGESTED PRICE:** $59.00
**HARDWARE:** Apple II Series; Commodore 64; IBM PC; TRS-80; Tandy 1000
**DESCRIPTION:** This is a game format program that requires students to generate and test hypotheses. In order to proceed through the king's castle, students must determine numerical rules. This program includes 6 levels of difficulty.
**EVALUATION:** *EPIE*

## PROBLEM SOLVING

**CONCEPT:** Problem Solving
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** The Right Turn
**PUBLISHER:** Sunburst Communications
39 Washington Ave.
Pleasantville, NY 10570-9971
**SUGGESTED PRICE:** $59.00
**HARDWARE:** Apple II Series; Commodore 64; IBM PC; Tandy 1000
**DESCRIPTION:** This is a program designed to develop student mathematical skills in rotation and transformation. Patterns are created by students who experiment with different transformations. Patterns can also be created and transformed by the computer. The challenge for students is to determine how to flip or rotate the computer generated pattern back to the original transformation.

**CONCEPT:** Problem Solving
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** The Factory
**PUBLISHER:** Sunburst Communications
39 Washington Ave.
Pleasantville, NY 10570-9971
**SUGGESTED PRICE:** $59.00
**HARDWARE:** Apple II Series; Atari; Commodore 64; IBM PC; TRS-80; Tandy 1000
**DESCRIPTION:** Student skills in visual discrimination, spatial perception, logic, and sequence are developed. Students are challenged to create geometric products on an assembly line. Problem solving strategies include Analysis of a Process, Working Backwards and Determining Sequences.
**EVALUATION:** *Computers in the Schools*, Spring, 1985; *Classroom Computer Learning*, October, 1983; *Courseware Report Card*, June, 1983

**CONCEPT:** Problem Solving
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Algebra Word Problems II; Algebra Word Problems III
Algebra Word Problems IV
**PUBLISHER:** Queue, Inc.
798 North Ave.
Bridgeport, CT 06606
1-800-232-2224
**SUGGESTED PRICE:** $34.95 for each program
**HARDWARE:** Apple II Series
**DESCRIPTION:** These programs provide students with practice in solving word problems covering a wide range of topics. Algebra Word Problems II presents problems solving for unknowns in ratios, levers and see-saws, work, and the perimeter of squares and rectangles. Algebra Word Problems III includes problem solving for the area of rectangles and squares, percents, motion and numbers. Algebra Word Problems IV provides practice concerning problems involving coins, age relationships, investments, and mixtures.

**CONCEPT:** Problem Solving
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Guess My Rule
**PUBLISHER:** HRM Software
175 Tompkins Ave.
Pleasantville, NY 10570
**SUGGESTED PRICE:** $59.00
**HARDWARE:** Apple II Series
**DESCRIPTION:** Students are challenged to determine rules or algorithms stored by the computer. Students enter numerical data and the result is displayed by the computer. New rules can be added to the list to provide challenges to other students. This program can be adjusted to fit the mathematical background of the student. A teacher's guide is included.

**CONCEPT:** Problem Solving
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Probability Through Problem Solving
**PUBLISHER:** MicroMedia
172 Broadway
Woodcliffe Lake, NY 07675
1-210-391-7555
**SUGGESTED PRICE:** $39.95
**HARDWARE:** Apple II Series
**DESCRIPTION:** This tutorial is designed to introduce students to probability concepts. Students are allowed to choose from a menu that includes Marbles in a Bag, Coins, Playing Cards, Number Cards, Marble Bag Complex, A Game, and Self Test. A teacher's guide is included.

## RATIO AND PROPORTION

**CONCEPT:** Ratio and Proportion
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Ratio and Proportion
**PUBLISHER:** Educational Activities
P.O. Box 392
Freeport, NY 11520
**SUGGESTED PRICE:** $59.95
**HARDWARE:** Apple II Series
**DESCRIPTION:** This software contains five tutorial programs which include Introduction to Ratios, Two Ways to Write Ratios, Writing Equivalent Ratios, Introducing Proportions and Using Cross Products. Each tutorial utilizes a diagnostic approach by examining student response and branching students to an appropriate section within the tutorial. Also included are a random word problem generator for the proportion programs and two quiz programs.
**EVALUATION:** *Mathematics Teacher*, May, 1985

**CONCEPT:** Ratio and Proportion
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Converting Fractions and Percents: Problems with Percents
**PUBLISHER:** Educational Activities
P.O. Box 392
Freeport, NY 11520
**SUGGESTED PRICE:** $59.95
**HARDWARE:** Apple II Series; Commodore 64; TRS-80; IBM PC
**DESCRIPTION:** This tutorial teaches conversion of fractions to percents and percents to fractions. A lesson is included that teaches students how to set up proportions. Quizzes as well as a management system for monitoring student progress are included.
**EVALUATION:** *InfoWorld*, November 23, 1981

**CONCEPT:** Ratio and Proportion
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Test Problems: Algebra, Calculus, Geometry, Statistics, Ratios, Exponents
**PUBLISHER:** PMI, Inc.
P.O. Box 35408
Dallas, TX 75235
1-214-252-3540
**SUGGESTED PRICE:** $30.00
**HARDWARE:** Apple II Series; Commodore 64; Pet
**DESCRIPTION:** The program is a tutorial comprised of practice problem sequences. Teacher support materials are included.

## RATIO AND PROPORTION

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|---|---|
| CONCEPT: | Ratio and Proportion |
| LEVEL: | Grades 9 to 12 |
| SOFTWARE TITLE: | High School Math Competency |
| PUBLISHER: | Learning Arts<br>P.O. Box 179<br>Wichita, KS 67201 |
| SUGGESTED PRICE: | $99.99 |
| HARDWARE: | TRS-80 |
| DESCRIPTION: | This is a drill and remediation program in basic mathematics designed for high school students. Topics included are Whole Numbers, Fractions, Decimals, Basic Percent, Primes and Factors, Integers, Algebra, Geometry, Ratio and Proportion, Probability, Statistics, Percent, Word Problems, Money Problems and Miscellaneous Problems. |

## STATISTICS

**CONCEPT:** Statistics
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Graphs: Means, Median and Mode
**PUBLISHER:** Educational Activities
P.O. Box 392
Freeport, NY 11520
**SUGGESTED PRICE:** $59.95
**HARDWARE:** Apple II Series; Commodore 64; TRS-80; IBM PC
**DESCRIPTION:** This is a tutorial that teaches the fundamentals for reading graphs. Emphasis is place on finding and comparing the mean, median and mode. Quizzes are included as well as a management system for monitoring student progress.

**CONCEPT:** Statistics
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Percentages
**PUBLISHER:** Educational Activities
P.O. Box 392
Freeport, NY 11520
**SUGGESTED PRICE:** $59.95
**HARDWARE:** Apple II Series; Commodore 64; TRS-80; Atari; Pet
**DESCRIPTION:** This software consists of three separate programs in both tutorial and drill formats. Introduction to Percent, the first program, involves the conversion of a decimal to percent and a percent to a decimal. Fractions as a Percent, the second program, deals with rewriting fractions as a percent. Finding the Percent of a Number, the third program, involves the conversion of a number to a percent. Also included is documentation.

**CONCEPT:** Statistics
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Chance Encounters: Fundamentals of Probability and Statistics
**PUBLISHER:** Educational Activities
P.O. Box 392
Freeport, NY 11520
**SUGGESTED PRICE:** $99.95
**HARDWARE:** Apple II Series
**DESCRIPTION:** This consists of seven lessons which include Basic Theory and Concepts, Combining Events, Independent Events and Conditional Probability, Combinatorics, Distributions, Statistics Guessing, and Probability Simulation. At the end of each lesson, a quiz determines where students are branched. Also included is a management system for monitoring student progress.

**CONCEPT:** Statistics
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Test Problems: Factors, Interest, Statistics, Trigonometry, Calculus, Percents, Bases, Exponents
**PUBLISHER:** PMI, Inc.
P.O. Box 35408
Dallas, TX 75235
1-214-252-3540
**SUGGESTED PRICE:** $30.00 for each program
**HARDWARE:** Apple II Series; Commodore 64; Pet
**DESCRIPTION:** This tutorial is comprised of practice problem sequences. Teacher support materials are included.

**CONCEPT:** Statistics
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Statistics and Graph
**PUBLISHER:** Queue, Inc.
798 North Ave.
Bridgeport, CT 06606
1-800-232-2224
**SUGGESTED PRICE:** $39.95
**HARDWARE:** Apple II Series
**DESCRIPTION:** This software utilizes histograms to present ratios. Topics presented are Median, Mean, Frequency Distributions and Averages from Given Scales. A glossary and screen calculator are included.

**CONCEPT:** Statistics
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Averages: Mode, Median, Mean
**PUBLISHER:** Control Data Publishing-Plato
P.O. Box 261127
San Diego, CA 92126
**SUGGESTED PRICE:** $39.95
**HARDWARE:** Apple II Series
**DESCRIPTION:** This program contains four lessons. A set of problem solving exercises is included at the end of each lesson. The program comes with a help mode and graphic calculator for mathematic computations. A student and teacher manual are included.

## STATISTICS

**CONCEPT:** Statistics
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Probability
**PUBLISHER:** Control Data Publishing-Plato
P.O. Box 261127
San Diego, CA 92126
**SUGGESTED PRICE:** $39.95
**HARDWARE:** Apple II Series
**DESCRIPTION:** Topics included in these four lessons are The Meaning of Chance, Binomial Probability and A Probability Experiment. This program includes a help mode and graphic calculator for mathematic computations. A student and teacher manual are included.

**CONCEPT:** Statistics
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** High School Math Competency
**PUBLISHER:** Learning Arts
P.O. Box 179
Wichita, KS 67201
**SUGGESTED PRICE:** $99.99
**HARDWARE:** TRS-80
**DESCRIPTION:** This is a drill and remediation program in basic mathematics designed for high school students. Topics included are Whole numbers, Fractions, Decimals, Basic Percent, Primes and Factors, Integers, Algebra, Geometry, Ratio and Proportion, Probability, Statistics, Percent, Word Problems, Money Problems and Miscellaneous Problems.

**CONCEPT:** Statistics
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Statistics Volume I: Descriptive Statistics and Introduction to Probability
**PUBLISHER:** Prentice-Hall, Inc.
P.O. Box 500
Englewood Cliffs, NY 07632
1-201-592-2000
**SUGGESTED PRICE:** $39.95
**HARDWARE:** Apple II Series; Commodore 64; IBM PC
**DESCRIPTION:** This program is designed to introduce students to the basic concepts of descriptive statistics and probability. Included are topics such as The Probability of Events and Methods of Compiling Data.

**CONCEPT:** Statistics
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Statistics Volume II: Permutations, Combinations, and Probability
**PUBLISHER:** Prentice-Hall, Inc.
P.O. Box 500
Englewood Cliffs, NY 07632
1-201-592-2000
**SUGGESTED PRICE:** $39.95
**HARDWARE:** Apple II Series; Commodore 64; IBM PC
**DESCRIPTION:** This software includes topics such as Measures of Central Tendency, Binomial Expansions, Probability of Mutually Exclusive Events, Probability of Independent Events and Frequency Distributions.

**CONCEPT:** Statistics
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Descriptive Statistics
**PUBLISHER:** Queue, Inc.
562 Boston Ave.
Bridgeport, CT 06610
1-800-232-2224
**SUGGESTED PRICE:** $39.95
**HARDWARE:** Apple II Series
**DESCRIPTION:** This tutorial provides students with an introduction to descriptive statistics. Topics include Measures of Central Tendency and Measures of Variability. This program also uses histograms to plot student entered data.
**EVALUATION:** *Mathematics and Computer Education*, Fall, 1982

**CONCEPT:** Statistics
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Probability Through Problem Solving
**PUBLISHER:** MicroMedia
172 Broadway
Woodcliffe Lake, NY 07675
1-210-391-7555
**SUGGESTED PRICE:** $39.95
**HARDWARE:** Apple II Series
**DESCRIPTION:** This is a tutorial designed to introduce students to probability concepts. Students are allowed to choose from a menu that includes the following: Marbles in a Bag, Coins, Playing Cards, Number Cards, Marble Bag Complex, A Game, and Self Test. A teacher's guide is included.

## TRIGONOMETRY

**CONCEPT:** Trigonometry
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Test Problems: Factors, Interest, Statistics, Trigonometry, Calculus, Percents, Bases, Exponents
**PUBLISHER:** PMI, Inc.
P.O. Box 35408
Dallas, TX 75235
1-214-252-3540
**SUGGESTED PRICE:** $30.00
**HARDWARE:** Apple II Series; Commodore 64; Pet
**DESCRIPTION:** This program is a tutorial comprised of practice problem sequences. Teacher support materials are included.

**CONCEPT:** Trigonometry
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Trigonometry Electronic Blackboard
**PUBLISHER:** Wadsworth Electronic Publishing Company
10 Davis Dr.
Belmont, CA 94002
**SUGGESTED PRICE:** $100.00
**HARDWARE:** Apple II Series
**DESCRIPTION:** This software contains two disks and serves as an introduction to trigonometry. Topics include Wrapping Functions, Special Angles, and Graphing Trigonometric Functions.

**CONCEPT:** Trigonometry
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Discovery Learning in Trigonometry
**PUBLISHER:** PMI, Inc.
P.O. Box 35408
Dallas, TX 75235
1-214-252-3540
**SUGGESTED PRICE:** $75.00
**HARDWARE:** Apple II Series; Commodore 64; Pet
**DESCRIPTION:** This program is designed to have students induce the trigonometric concept from a series of examples. Students enter functions in BASIC notation and observe cause and effect relationships. Topics included are Trigonometric Identities, Trigonometric Non-identities and Polar Coordinates. A student guide is included.

**CONCEPT:** Trigonometry
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Introduction to Trigonometry
**PUBLISHER:** Queue, Inc.
798 North Ave.
Bridgeport, CT 06606
1-800-232-2224
**SUGGESTED PRICE:** $59.95
**HARDWARE:** Apple II Series
**DESCRIPTION:** This is a tutorial that covers the following topics: Sines, Cosines, Tangent, Cotangent, Secant, Cosecant and Logarithms. Drill and practice exercises are included in the program.
**EVALUATION:** *Mathematics and Computer Education*, Fall, 1985

**CONCEPT:** Trigonometry
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** RSI Trigonometry
**PUBLISHER:** Queue, Inc.
798 North Ave.
Bridgeport, CT 06606
1-800-232-2224
**SUGGESTED PRICE:** $39.95
**HARDWARE:** Apple II Series; IBM PC
**DESCRIPTION:** This program consists of two sections. The first section concerns concepts in trigonometric functions. The second section deals with applications of trigonometric functions.

**CONCEPT:** Trigonometry
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Honors Trigonometry
**PUBLISHER:** Queue, Inc.
798 North Ave.
Bridgeport, CT 06606
1-800-232-2224
**SUGGESTED PRICE:** $39.95
**HARDWARE:** Apple II Series; IBM PC
**DESCRIPTION:** Students are presented with advanced topics in trigonometry. Topics included are Polar Coordinates, Law of Cosines, Law of Sines, Trigonometric Identities, and Circular Functions.

## TRIGONOMETRY

**CONCEPT:** Trigonometry
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Trigonometry
**PUBLISHER:** Queue, Inc.
798 North Ave.
Bridgeport, CT 06606
1-800-232-2224
**SUGGESTED PRICE:** $34.95
**HARDWARE:** Apple II Series
**DESCRIPTION:** This is a software program directed towards helping students understand the functions of sine and cosine.

**CONCEPT:** Trigonometry
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Trigs in Space: Using Radians and Degrees
**PUBLISHER:** HRM Software
175 Tompkins Ave.
Pleasantville, NY 10570
**SUGGESTED PRICE:** $49.00
**HARDWARE:** Apple II Series; Commodore 64
**DESCRIPTION:** This program teaches radian measurement in a game format. In order to destroy approaching enemy spacecraft, students must rotate the spaceship to the correct position and fire. Position is determined by utilization of radar reports and trigonometric relations of angles.

**CONCEPT:** Trigonometry
**LEVEL:** Grades 10 to 12
**SOFTWARE TITLE:** Wepco Electronic Study Guide for Trigonometry
**PUBLISHER:** Wadsworth Electronic Publishing Company
10 Davis Dr.
Belmont, CA 94002
**SUGGESTED PRICE:** $49.95 for each disk; $275.00 for the set of six disks
**HARDWARE:** Apple II Series
**DESCRIPTION:** This software contains six disks: Getting Ready for Trigonometry, Trigonometric Functions, Trigonometric Graphing, Analytic Trigonometry, Oblique Triangles and Vectors, and Complex Numbers. A 64 page teacher's guide is included that contains a listing of the table of contents for each diskette, teaching suggestions and a summary of the prompts and commands.
**EVALUATION:** *Mathematics and Computer Education*, Spring, 1985

**CONCEPT:** Trigonometry
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Interactive Trigonometry
**PUBLISHER:** Opportunities for Learning, Inc.
20417 Nordhoff St.
Chatsworth, CA 91311
1-818-341-2535
**SUGGESTED PRICE:** $199.95
**HARDWARE:** Apple II Series
**DESCRIPTION:** This tutorial contains a set of 10 disks. Some of the concepts covered include Trigonometric Functions, Trigonometric Identities, Inverses of Trigonometric and Circular Functions, Vectors, and Solving Right Triangles. A diagnostic test is included to determine the level of entry for individual students.

**CONCEPT:** Trigonometry
**LEVEL:** Grades 9 to 12
**SOFTWARE TITLE:** Discovery Learning in Trigonometry
**PUBLISHER:** Conduit
P.O. Box 388
Iowa City, IA 52244
**SUGGESTED PRICE:** $75.00
**HARDWARE:** Apple II Series
**DESCRIPTION:** Students are allowed to manipulate visual displays of trigonometric relationships. Students are not told the concept or principle, but must induce the concept from examples. The following topics are included: Problem Solving Graphics, Orientation, Exploration and Discovery, Holistic Graphics, and Polar Coordinates. A student guide is included.
**EVALUATION:** *Mathematics and Computer Education*, Spring, 1983; *The Mathematics Teacher*, June, 1983; *The Curriculum Review*, May, 1983

# PART C

# EVALUATING SOFTWARE FOR LEARNING OUTCOMES

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# Evaluating Software for Learning Outcomes

With a growing abundance of educational software, teachers face difficult selection decisions. Often, their choices are constrained by limited funds for computer materials and tight classroom schedules. In these circumstances, teachers seek the educational software most likely to produce **positive learning outcomes.**

Numerous "software evaluation" systems have emerged to help teachers select software. Unfortunately, nearly all software evaluation systems are heavily weighted in computer-related dimensions such as error-handling, aesthetic considerations such as the quality of screen displays, and content related issues of scope, sequence, and accuracy. These characteristics, although important, do not address the essential question: **Is the software's design consistent with our knowledge of how students learn?** We contend that an adequate software evaluation model must arise from a clear perspective of the student as a learner.

The text material of this chapter leads to software evaluation questions and a sample software evaluation form. It can serve as a guide to identifying software likely to produce positive learning outcomes. Using this approach does not exclude using additional software evaluation procedures that emphasize computer and curriculum related issues. However, it is suggested that if a particular software does not meet certain standards of probable learning effectiveness, it is unlikely to prove satisfactory in everyday teaching situations.

## Human Cognition

Over the past decade, research on human cognition has revealed new insights into the mental processes involved in learning, remembering, reasoning, and problem solving. These findings also have implications for the design and evaluation of educational software. An overview of the components, functions, and limitations of the human cognitive system provides a framework for understanding why some educational software which "looks good" fails to produce positive learning outcomes.

Noted educational psychologist Robert M. Gagne (1984) identified five categories of learned capabilities involved in complex human performance:

- verbal knowledge
- intellectual skills
- cognitive strategies
- motor skills
- attitudes

These five capabilities are distinguished because each requires its own unique set of **external conditions** such as identifying goals, determining prerequisite knowledge and providing corrective feedback. Acquiring each capability is also contingent on the presence of a unique set of **internal conditions** in a learner: prerequisite verbal knowledge, intellectual skills, motor skills, and attitudes. Therefore, an analysis of the internal and external conditions necessary for acquiring a targeted skill must be part of educational software evaluation.

What are the basic elements of a human cognitive system? Contemporary theory suggests that, at the very least, the model of a human cognitive system must be capable of describing: a) the reception of sensory information; b) how information is represented in memory; c) the different states of information (aware vs. unaware); d) processes related to learning, remembering and thinking; and, e) the generation of overt behavior (Anderson, 1983; Bower, 1975). A model depicting these elements as they may be affected through the interaction with a computer system is presented in Figure 1. The arrows in the diagram represent the flow of information from a computer's screen through the various stages of cognitive processing. A careful study of this model and the descriptions of it's components will promote a better understanding of the conditions necessary to achieve a particular learning outcome.

## Components of a Sensory System

What is the chain of events involved in a learner's cognitive response to computer produced stimuli? Verbal, auditory, and visual-spatial information from a computer stimulates the learner's sense receptors. In turn, these sense receptors transform the information into neural codes. Neural codes are then preserved, or "stored," briefly, usually a few hundredths of a second, in the learner's short term sensory register (Sperling, 1960). In this brief interval, information is almost exactly preserved. However, human attention is limited. Unless a student continuously attends to a computer display, sensory information is quickly lost. Sensory information which does not continue to receive attention "decays," or vacates, the sensory register.

It is useful to think of attention as a filter which restricts the amount of information that can make contact with the long-term memory system. Note in Figure 1 that only a few elements of a computer display stored in the sensory register (represented by the arrows) is passed through this attention filter.

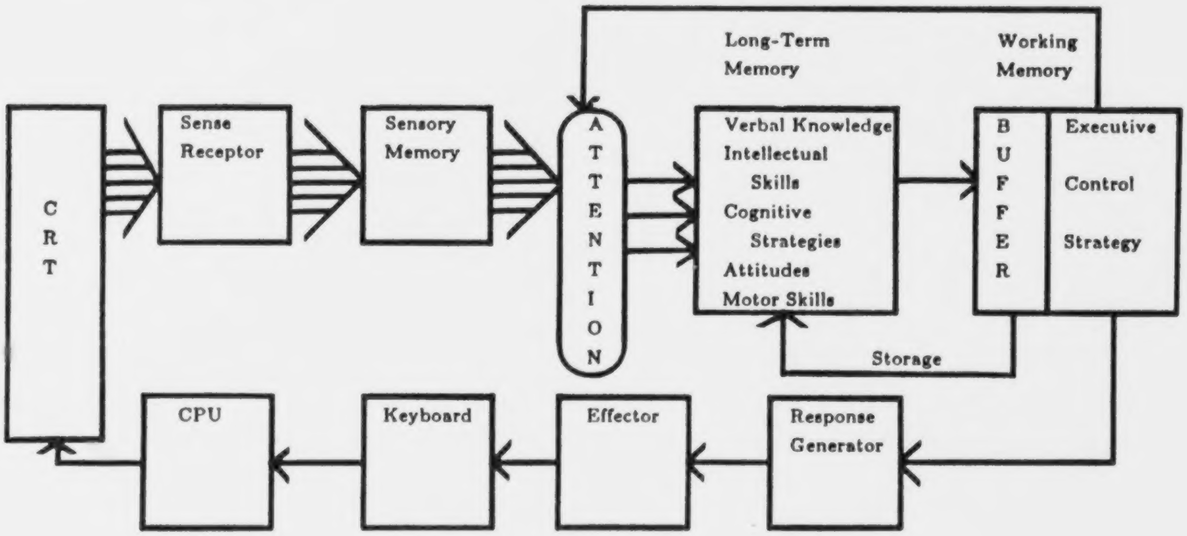

Figure 1

### Long-Term Memory

Within a few seconds, sensory information which receives continued attention activates knowledge in long-term memory. Information stored in long-term memory consists of attitudes, beliefs, sequences of motor skills, strategies for learning and problem solving, intellectual skills, and verbal knowledge.

A consistent finding from research on long-term memory for text, pictures, conversations or other events, is that people do not remember exact details. Rather, it appears that our experiences are transformed into an abstract memory code (proposition) that preserves the meaning of an experience. Controversy remains over exactly how knowledge is stored in long-term memory. Current research suggests that knowledge is organized hierarchically. It may be helpful to think about a taxonomy with superordinate and subordinate concepts that are linked together to form a network. Reading a word results in the activation of its long-term memory code and the spreading of activation to related concepts. For example, comprehension of the sentence "mammals are warm-blooded" depends on the activation of information (propositions) related to mammals (e.g., live birth, lungs), specific instances of mammals (e.g., dog, whale, elephant) and being warm-blooded (consistent body temperature). Other knowledge (e.g., intellectual skills, and cognitive strategies) have different representations in long-term memory that will be discussed later in this section.

### Working Memory

Verbal knowledge, intellectual skills and cognitive strategies, activated by the information displayed on the computer monitor, become part of the students' working memory system. A useful analogy is to think of working memory as a workbench where conscious mental processing is carried out (Klatzky, 1975). Working memory is a complex and powerful memory system. Note in Figure 1 that working memory consists of a short-term memory buffer capable of holding a small amount of verbal information called "chunks," visual-spatial information and a central executive (Baddeley and Hitch, 1974).

Simon (1980) defines a chunk as any perceptual configuration of visual or auditory stimuli that is familiar and recognizable. Examples of chunks include words, phrases and rules. On the average, the short-term memory buffer can maintain about four chunks of information in an active (conscious) state. However, chunks may be very large and complex. The central executive, governed by the learner's goals and motives, is responsible for selective attention and a variety of other control processes which: a) modify and transform information in the short-term memory buffer; b) store information in long-term memory; and, c) retrieve information from long-term memory.

### Storage

First, examine the role of selective attention depicted in Figure 1. Note the arrow that connects the working memory system with the process of attention. Depending on features of the computer display, goals and motives, students will selectively attend to certain information on the display at the expense of other information. Storing one new chunk of information to long-term memory requires about eight seconds of attention. However, several minutes of attention may be required to add a complex chunk of information to long-term memory if the elementary chunks have to be acquired (stored in long-term memory) at the same time (Simon, 1980).

The storage of information in long-term memory can be hastened somewhat by invoking other control processes such as rehearsal, elaboration and organizational strategies. Rehearsal may be thought of as the subvocal recitation of chunks within the short-term memory buffer. Reciting a phone number until it has been dialed, mentally reciting a short list of items needed for the evening meal on the way to the grocery store or the answer to a question asked by a teacher are examples of rehearsal. Interruption of the rehearsal cycle (e.g., a busy signal, a near accident on the way to the store, or a student laughing in the classroom) usually results in loss of the information from short-term memory. To reactivate information, one must search long-term memory for the phone number, recipe or question. If retrieval failure occurs, we must return to external sources such as the telephone directory, recipe book, or the teacher. Although rehearsal promotes the storage of information in long-term memory, there are more efficient methods.

The addition of new chunks of information into long-term memory is facilitated through elaboration. Elaboration involves the retrieval of additional information that is related to new chunks of information from long-term memory. Noting similarities and dissimilarities of new information in relation to one's existing knowledge base contributes to the meaning and memorability of new information. Techniques that involve the construction of visual imagery are also considered examples of elaboration strategies. Examples of visual imagery are discussed later in this section. Similarly, organizational strategies consist of a conscious effort to label and categorize the contents of short-term memory. When properly activated, the control processes of rehearsal, elaboration and organization can result in more rapid acquisition and storage of new information as well as more efficient retrieval.

### Retrieval

When the short-term memory buffer contains a proposition, plans for guiding a search of long-term memory are retrieved, or activated, in the working memory system. Retrieval strategies typically involve a systematic plan for selecting cues from questions which are then used to activate relevant knowledge structures in long-term memory. Students determine whether information activated will be useful for answering a question. If a student uses elaboration or organization strategies for storing information, the cues will make quick contact with relevant information. If a question states a problem to be solved, plans for solving the problem are assembled in working memory under the control monitor in much the same way. These processes are described in greater detail later in this section.

### Response Generation and Performance

Plans for achieving a goal are transmitted to a structure called a **response generator**. The response generator selects muscle groups to respond to a goal and perform the necessary sequence of movements. Subsequently, these messages are transmitted to **effectors**, resulting in overt action. In Figure 1, overt actions consist of pressing a key or sequence of keys on a computer's keyboard. Student actions are processed by the instructional program which modifies the information on the monitor and the information processing cycle begins again.

# Categories of Learning Outcomes

## Verbal Knowledge

Verbal knowledge represents much of what students are expected to learn in school. Verbal knowledge is a fundamental building block for more complex forms of learning. However, the meaning of words is but a small fraction of the verbal knowledge that students are expected to learn. **Discourse** is a complex form of verbal knowledge. Examples of discourse are the Pledge of Allegiance, the National Anthem, the Bill of Rights, or a poem. Often, students are asked to memorize discourse in verbatim form. However, Gagne warns that verbatim recall of discourse does not guarantee that students have extracted meaning.

People rarely store verbal knowledge verbatim. Verbal knowledge is stored in long-term memory as a collection of **propositions.** A proposition is the smallest unit of knowledge that can stand as a separate assertion (Anderson, 1984). A proposition can be represented as a list consisting of a relational term (verb, adjectives, predicate) and arguments (noun). Relational terms provide connections among the arguments. The general form of a proposition is:

(relation, argument 1, argument 2)

Consider the following statements: "The capital of Colorado is Denver" and "2 + 3 = 5." Each statement may be expressed in the following propositional notation:

(is capital of, Denver, Colorado)
(is 5, 2 + 3)

Evidence of this underlying structure is provided by the finding that students have difficulty remembering whether they have seen the sentences: "Denver is the capital of Colorado" or "The Capital of Colorado is Denver." Nevertheless, they have learned the capital of Colorado. The point is that **memory for verbal information is reconstructive.**

Propositions are not stored as a collection of unrelated facts. They are encoded into long-term memory as organized networks. Depending on instruction and the students' organizational strategies, the associative network of states and capitals may be organized according to geographic region, the alphabet, or order of statehood. Likewise, number facts may be organized by families or in a two dimensional table. Everyone stores propositions differently.

Working memory extracts propositions from discourse and assembles them to derive meaning from a message. Computer displays containing numerous propositions increase working memory demands and decrease comprehension. Therefore, effective educational software limits the amount of information and propositions presented on a single screen display.

## Internal Prerequisites to Verbal Knowledge

Evaluation of software designed to teach verbal knowledge must begin by identifying prerequisite internal conditions of knowledge and skills. Of the above propositions, an evaluator might state that a software's effectiveness depends on students having previously learned concepts of state, capital, numerosity, magnitude, and combination. Also, students must know the linguistic rules underlying comprehension. A learner must possess an equal or higher reading level than required by the computer lesson or frustration will impede the acquisition of verbal knowledge.

## External Prerequisites to Verbal Knowledge

After identifying necessary internal conditions, an evaluator should identify external prerequisites. First, does the software inform the learner of the lesson's goals and objectives? Second, does the software pretest, activate or teach the internal prerequisites? Other factors having a pronounced effect on verbal knowledge acquisition include:

### Selective Repetition with Feedback

Recall and recognition of verbal knowledge improves through repetition. However, students become bored with software that continually repeat well-learned information. Therefore, software that monitors student performance and **presents unlearned items** offers a greater challenge while maximizing learning (Chant & Atkinson, 1978).

### Encoding Context

The learning context profoundly affects a students' ability to retrieve information from long-term memory (Bower, 1972; Gartman & Johnson, 1972). Programs presenting verbal information in varied contexts establish more retrieval cues for recalling information.

### Organizational Strategies

Teaching strategies for organizing verbal information improves recall by providing a systematic method of searching long-term memory (Bower, Clark, Lesgold, & Winzenz, 1969). Therefore, an evaluator should ask, "Does the software contain an explicit organizational strategy for learning and remembering?"

### Mnemonic Strategies

Persons demonstrating exceptional memory performance use techniques that make novel information meaningful. One powerful technique, the keyword method, uses imagery to link new information to the learner's existing knowledge base. This technique has been used effectively in learning a second language vocabulary, expanding native language vocabulary, and in learning scientific classification schemes. Even learning disabled students benefit from using mnemonic techniques (Mastropieri, Scruggs, & Levin, 1985).

## Evaluation Questions for Verbal Knowledge

- Does the software teach the meaning of concepts as opposed to verbatim learning?
- Does the software assess prerequisite knowledge and skills?
- Does the software teach prerequisite knowledge and skills?
- Does the software link new concepts to existing knowledge?
- Does the software limit the amount of information presented on a single screen?
- Does the software monitor student performance to provide selective repetition and feedback?

- Does the software provide varied contexts for the encoding and retrieval of information?

- Does the software help students tie new information to existing information?

## Intellectual Skills

Intellectual skills differ from verbal knowledge. Intellectual skills refer to "knowing how," as opposed to "knowing that" (Gagne, 1985). Intellectual skills, sometimes termed procedural knowledge or production systems, underlay the basic skills of reading, writing, and mathematics. These "basic skills" in turn provide essential procedures for learning about other subjects including music, social studies and art.

Generally, intellectual skills involve symbol manipulation such as calculating, classifying, distinguishing and transforming symbol systems. Intellectual skills range from simple (calculating a sum of two numbers or forming plurals) to complex (using metaphors and analogies in writing, or proving a geometric theorem).

A basic intellectual skill is represented in long-term memory as a production system consisting of rules. Most human behavior is rule-governed. This does not mean that an individual can always state the rule used to accomplish a goal. Still, their behavior appears to be rule governed. Young children and many adults cannot state the rules of grammar, yet their language conforms to linguistic rules. For example, when children are asked to form the plural of the nonsense word "wug," a typical reply would be "wugs." This response conforms to the rule: "If the goal is to form a plural noun, and the noun ends in a hard consonant, then generate noun + s."

Intellectual skills are stored in long-term memory as production systems. Production systems are organized as rules consisting of goals, conditions and action propositions. The general form of a production system can be represented as follows:

| | |
|---|---|
| IF | the goal is to achieve X and condition Y is true |
| THEN | perform action Z |

Consider the production system for achieving subject-verb agreement:

| | |
|---|---|
| IF | the goal is to achieve subject-verb agreement and the subject is singular |
| THEN | generate (retrieve) a singular verb |

Changes in production systems occur as a child matures and gains experience in symbol manipulation. For example, in learning to perform single digit addition, children use counting strategies. Older children and adults typically retrieve the answer from memory (Ashcraft, 1982). Given the problem 2 + 3 = ?, differences in the production systems of children and adults can be represented as follows:

**Child:**

IF the goal is to find a sum and the two addends are 2 and 3

THEN set a counter equal to the largest addend (3) and increment the counter 2 times

**Adult:**

IF the goal is to find a sum and the two addends are 2 and 3

THEN search memory to retrieve the answer

Adults typically retain a counting production system and revert to it when memory retrieval fails. Elapsed time in problem solving and the types of errors that children and adults make support this interpretation of simple mental addition.

Acquiring an intellectual skill consists of three stages: cognitive stage, associative stage, and autonomous stage (Anderson, 1983; Fitts & Posner, 1967). Acquiring a skill begins with developing verbal knowledge (cognitive stage) about the steps involved in the skill. That is, students store facts related to a skill in long-term memory by rehearsing the fact while they perform the skill.

When learning to strum a melody's chord progression on a guitar, students must first learn to position their fingers on the fingerboard while striking the strings to produce a chord. Even after students have learned to produce chords in the correct order, in the cognitive stage their knowledge is inadequate for skilled performance. Students must also learn to produce the chords in tempo.

Having established the relevant verbal knowledge in long-term memory, transition to the associative stage begins. With continuing feedback, learners begin to detect and eliminate errors in their understanding of how to perform the skill (play the guitar chords). Associations between the components of a skill are strengthened.

Now a learner's knowledge is transformed into a procedural form, a **production system**. Transition to the autonomous stage is characterized by an increase in performance speed and accuracy and the disappearance of verbal mediation during performance. A learner no longer thinks about the required steps. He or she may even lose the ability to articulate the verbal knowledge related to the skill.

Improvements in the performance of an intellectual skill during the autonomous stage occur in smaller and smaller increments. Diminishing returns are associated with practice. There appear to be no cognitive limitations on the speed of performing an intellectual skill during the autonomous stage. Any limitations are imposed by involved musculature or learner motivation.

### Internal Prerequisites for Acquiring Intellectual Skills

Evaluating software designed to teach intellectual skills begins with identifying the internal prerequisites for successful learning (e.g., knowledge and skills). An answer to the question, "What verbal knowledge and subordinate skills are learners presumed to possess?", must be obtained.

## External Prerequisites to Intellectual Skills

Gagne (1985) provided a concise summary of the external conditions or "events of instruction" necessary for acquiring intellectual skills. An overview of these conditions and their implications for software evaluation follows.

### Cognitive Stage

Does instruction begin with a statement of the goals and performance expected when learning is complete? Too often, instructional software simply informs learners that they will learn about a subject without stating the conditions or desired outcome. For example, students should be informed that they will learn a two-column procedure for proving two triangles congruent using the side-side-side and side-angle-side postulates. The statement "you will learn geometric proofs" is inadequate.

Does instruction pretest, activate, or teach the components, subordinate verbal knowledge and procedural skills, comprising the intellectual skill? One cannot assume that students possess appropriate internal conditions or that students will recall information on their own.

### Associative Stage

Does the software use explicit cues that lead students to associate the components of the skill in the proper order? There should be no mystery shrouding the steps leading to the successful performance of the skill.

Does the instructional software require the learner to demonstrate concrete instances of the rule or procedure? Does the software provide feedback on student understanding of a skill? Ideally, the software should diagnose which skill component is in error. However, here lies a major stumbling block to effective computer-based instruction. Programming computers to provide this kind of feedback has been extremely difficult and found to require tremendous amounts of computing power. (The reader is referred to Sleeman and Brown [1982].)

Does the software require students to make an explicit verbal statement of the rules underlying a skill? Although a student's ability to state a rule may diminish during the autonomous stage, it is usually helpful for a student to be able to verbalize a rule.

### Autonomous Stage

Does the instructional software involve spaced, or distributed, practice? Performance decrements often result from instruction that requires massed, intense practice. For example, spaced practice resulted in superior retention of algebraic rules in contrast to massed practice (Gay, 1973). Another aspect of practice that affects skill acquisition is part vs. whole learning. Does the software attempt to teach the skill in parts or in its entirety? Again, basic research has demonstrated that it is better to teach the entire sequence than subsections of the sequence (Schulz and Gorgein, 1976).

Does the software provide the student with varied contexts to demonstrate the application of the rule? As with verbal knowledge, varied contexts facilitate retrieval and transfer of learning.

### Evaluation Questions For Intellectual Skills

- Does the software pretest or teach prerequisite verbal knowledge?
- Does the software describe goals in detail?
- Does the software describe the performance level to be achieved?
- Does the software provide explicit cues to help students correctly sequence component skills?
- Does the software require students to provide concrete examples of a rule or procedure?
- Does the software provide feedback to students, enabling them to check for understanding?
- Can the software diagnose student errors?
- Does the software require students to verbalize their understanding of knowledge or a skill?
- Does the software teach the whole skill as opposed to separate component parts?
- Does the software provide for student practice of the whole skill?
- Does the software provide varied contexts in which students are required to apply a rule?

### Cognitive Strategies

Cognitive strategies refer to skills for managing attention, learning, remembering, reasoning and problem solving. They involve knowledge about one's cognitive functions and limitations. In contrast to "knowing that" or "knowing how," cognitive strategies are skills related to "learning how to learn." They support self-instruction and independent learning. In the learning model, cognitive strategies are executive control processes carried out in working memory.

Of all learning outcomes, the least is known about cognitive strategies and their transfer to novel situations and problems. Nevertheless, the software market is rife with software that claim to develop cognitive strategies. One example involving the use of computers to teach children problem solving and higher order cognitive strategies is the LOGO language (Papert, 1980). Few educators or computer scientists dispute LOGO's superiority as a programming language. There is skepticism, however, about the claims of learning outcomes resulting from learning how to program in LOGO. Most evidence from well-controlled studies fails to support claims that learning LOGO enhances problem solving skills. When asked to read a LOGO program and describe the function of each line, children could not demonstrate that they understood the concepts of sequentiality, recursion, or conditional statements, despite having used them in their own programs. Furthermore, students who had learned to program in LOGO did not demonstrate better planning skills than students who did not learn to program in LOGO (see Tetenbaum & Mulkeen, 1984 for further discussion).

One purpose for noting LOGO's inadequacies as a means for teaching general problem solving skills is to illustrate the difficulty of teaching general problem solving skills. There are many examples of other procedures for directly teaching problem solving that have had little success (Greeno, 1980; Newell, 1980). What has become clear from the research is that problem solving is far too complex to hope for identifying a small set of underlying skills.

Existing data also suggests that problem solving cannot be separated from its content domain. However, before a detailed discussion of the issues and criteria for judging problem solving software is presented, a few of the more cognitive strategies will be addressed. More is known about teaching cognitive strategies related to attention, encoding for storage in long-term memory, and retrieval from long-term memory, than is known about problem solving.

Like any other skill, learning to attend to important aspects of discourse can be taught. A promising technique involves using adjunctive questions inserted in the text (Rothkopf, 1970). Also, teaching students about the structure of text has been found to improve their attention to and their comprehension of important information.

Strategies for encoding, storing, and retrieving information in long-term memory distinguish between "good" and "poor" learners (Rohwer, 1975). Typically, capable learners are aware that if they want to remember a new concept they must do something with the information (Brown, 1978; Flavell, 1976). At the lowest level, this would involve rehearsing the information they wish to retain. However, there are more powerful strategies. Some of these strategies involve elaborating a new concept by relating it to something previously established in memory. Similarly, organizing and categorizing new information is tantamount to developing a plan for retrieving the information later. In other words, students learn to use the category label as a retrieval cue. Students may be taught these procedures through the insertion of prompts in the instructional software which require students to engage in a desired type of processing. Again, practice in varied contexts is an instructional component.

A more complex strategy involves using imagery. Information rich in imagery is remembered better than information low in imagery (Paivio, 1971). However, young children have difficulty generating their own imagery for new concepts. An example of this technique is the application of the keyword method for teaching mineral classification, involving hardness (Moh's scale), color, and use. First, students were taught rhyming pegwords for the numbers 1 through 10 to represent the hardness scale (1 = bun, 2 = shoe, 3 = tree, etc.). Then keywords that rhymed with some aspect of the mineral (e.g., pie for pyrite) were taught. For each mineral, an interactive image was developed containing the pegwords (hardness), keywords (rhyming with the mineral), color, and an object describing its use.

For example, the interactive image for pyrite contained a picture of a yellow pie (keyword and color attribute) supported by sticks (pegword for six on the hardness scale) with a bottle of acid (use) being poured onto the pie. This mnemonic technique was superior (94.8% recall) to either a free-study condition (76.7%) where students used their own strategies, or a direct instruction procedure (63.5%) where students received drill and practice on recalling the items and their attributes (Mastropieri, Scruggs, McLoone & Levin, 1985). Similar results occurred in foreign language and native language vocabulary acquisition. Finally, learners can be taught to develop their own visual images by demonstrating the technique. With younger children, software should provide interactive images. For older children and adults, it is better if the software requires the student to generate the interactive image on their own.

Now it is time to revisit issues in teaching problem solving skills. Earlier, the difficulty of separating a problem solving strategy from its content domain (e.g., mathematics) was noted. A detailed description of the problem solving strategies in various content domains would require several chapters if not volumes. Therefore, only fundamental knowledge about problem solving will be described to derive some general criteria for software evaluation. Readers interested in pursuing this research should consult Mayer (1985) for a discussion of problem solving in mathematics, Chi et al., (1981) for problems solving strategies in physics, and Anderson, Farrell, and Saunders (1984), for a comparison of expert and novice problem solving strategies in the development of computer software.

Problem solving behavior is goal directed. The most comprehensive analysis of problem solving was developed by Newell & Simon (1972). In their analysis, problem solving is conceptualized as the process of defining the problem space or state and then searching the problem state for a sequence of actions (operators) that transform the problem from the initial state to the goal state. To illustrate, consider the following algebraic word problem:

> Write an equation to represent the following relationship:
>
> There are twice as many male students on campus as female students. Let M stand for the number of males and F the number of females.

Developing an accurate representation (defining the problem state) of the problem is essential. The stated goal is to write an equation, not solve an equation. If students define the problem state as finding the number of males or females, students will probably decide that the problem cannot be solved and give up. However, if students define the problem state according to the goal provided, searching the problem state for a solution can begin.

Teaching students how to develop an accurate representation of the problem state is among the most difficult and neglected steps in education (Simon, 1980). Many of the errors students make in solving problems involve errors in the translation of a problem into a form that can be solved. For the problem above, it would be common for college students to write the equation as: $2M = F$. If students were given the number of females and asked to calculate the number of males, they would probably realize that they had made an error in writing the equation. The correct representation is $M = 2F$ or $1/2\ M = F$.

As problems become more complex, people often adopt general strategies in an attempt to find a solution. These general strategies are called heuristics. In contrast to rules or algorithms, which always produce the desired outcome, heuristics do not guarantee a solution. Heuristics are strategies that problem solvers use to guide their search of the problem space. A few of the more well known and successful heuristics are described below (Anderson, 1985; Wickelgren, 1974). Educational software should be carefully examined for these features before any claim is made that the software teaches students to become better problem solvers.

1. Difference-Reduction Method: Does the instructional software require students to set sub-goals that reduce differences between an initial problem state and the goal state?

2. Means-End Analysis: Does the instructional software lead students to: a) create sub-goals by defining the problem state as a collection of differences between the initial state and the goal state, and b) eliminate the most important difference first?

3. Working Backward: Does the instructional software demonstrate how a problem can be decomposed into an hierarchical set of sub-goals, and how solving the sub-goals at the bottom of the hierarchy can imply a solution to the problem?

4. Problem Solving by Analogy: Does the instructional software present the solution of a similar problem as a guide to finding the solution of the problem at hand?

5. Contradiction: Does the instructional software emphasize identifying contradictions proving the goal cannot be achieved from the information given?

Although these guidelines for evaluating "problem solving" software are general, they should be useful for determining if the software will be successful in teaching problem solving skills. In using these guidelines, remember that problem solving strategies must be taught in the context of a content domain.

### Evaluation Questions for Cognitive Skills

- Does the software pretest for or teach prerequisite verbal knowledge?
- Does the software require students to define a problem?
- Does the software direct students toward a precise goal?
- Does the software require students to set sub-goals?
- Does the software require students to decompose a problem into a hierarchical form and solve from the bottom up?
- Does the software provide a similar problem as a guide?
- Does the instructional software emphasize identifying contradictions?
- Does the software provide a context for the problem?

## Conclusions

Research on cognitive processes underlying human abilities has produced extensive knowledge about learning, remembering, reasoning, and problem solving. Although much remains to be learned, the knowledge that has been gained can be put to immediate use in designing and evaluating instructional materials and practices. The purpose of this section has been to provide an overview of cognitive processes and the criteria they imply for evaluating educational software. It is hoped that as a result of this evaluative approach, readers will be able to better select software that will enhance student learning.

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Belmont, CA 94002

# APPENDIX C

# SAMPLE SOFTWARE EVALUATION FORM

The following is a **sample software evaluation form** based on principles outlined in **Evaluating Software for Learning Outcomes.** No single evaluation form is best for every application. Use this software evaluation form only as a guide. Emphasize the questions that are most applicable to your teaching situation. Not all questions will apply to all teaching situations. Place less emphasis on what is less important in your classroom.

Software Title:

Publisher:

Price:

Required Hardware:

Description:

**Verbal Knowledge**

List the types of verbal knowledge that are intended to be taught by this software:

a)
b)
c)
d)
e)
f)
g)
h)
i)
j)

1 = Strongly Disagree 2 = Disagree 3 = Agree 4 = Strongly Agree

| | |
|---|---|
| 1 2 3 4 | The software teaches the meaning of concepts as opposed to verbatim learning. |
| 1 2 3 4 | The software assesses prerequisite knowledge and skills. |
| 1 2 3 4 | The software teaches prerequisite knowledge and skills. |
| 1 2 3 4 | The software links new concepts to existing knowledge. |
| 1 2 3 4 | The software limits the amount of information presented on a single screen. |
| 1 2 3 4 | The software monitors student performance to provide selective repetition and feedback. |
| 1 2 3 4 | The software provides varied contexts for the encoding and retrieval of information. |

**Intellectual Skills**

List the types of intellectual skills that are intended to be taught by this software:

a)
b)
c)
d)
e)
f)
g)
h)
i)
j)

1 = Strongly Disagree 2 = Disagree 3 = Agree 4 = Strongly Agree

1 2 3 4 The software pretests or teaches prerequisite verbal knowledge.

1 2 3 4 The software describes goals in detail.

1 2 3 4 The software describes the performance level to be achieved.

1 2 3 4 The software provides explicit cues to help students correctly sequence component skills.

1 2 3 4 The software requires students to provide concrete examples of a rule or procedure.

1 2 3 4 The software provides feedback to students, enabling them to check for understanding.

1 2 3 4 The software diagnoses student errors.

1 2 3 4 The software requires students to verbalize their understanding of knowledge or a skill.

1 2 3 4 The software teaches the whole concept or skill as opposed to separate component parts.

1 2 3 4 The software provides for student practice of the whole concept or skill.

1 2 3 4 The software provides varied contexts in which students are required to apply a rule.

## Cognitive Strategies

List the types of cognitive strategies that are intended to be taught by this software:

a)
b)
c)
d)
e)
f)
g)
h)
i)
j)

1 = Strongly Disagree 2 = Disagree 3 = Agree 4 = Strongly Agree

1 2 3 4 The software pretests or teaches prerequisite verbal knowledge.

1 2 3 4 The software requires students to define a problem.

1 2 3 4 The software directs students toward a precise goal.

1 2 3 4 The software requires students to set sub-goals.

1 2 3 4 The software requires students to decompose a problem into a hierarchical form and solve from the bottom up.

1 2 3 4 The software provides a similar problem as a guide.

1 2 3 4 The instructional software emphasizes identifying contradictions.

1 2 3 4 The software provides a context for the problem.

## OTHER ESSENTIAL TITLES FOR YOUR COMPUTER RESOURCES LIBRARY

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